LIBBY ASBESTOS SUPERFUND SITE
OPERABLE UNIT 3

DATA SUMMARY REPORT: 2007 TO 2011

Revision 0 – November 2013

Prepared for and with oversight by:

U.S. ENVIRONMENTAL PROTECTION AGENCY
Region 8

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Approved by:_____ Date: _____

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Acronyms and Abbreviations

ABS	activity-based sampling
AOC	Administrative Order on Consent
ATSDR	Agency for Toxic Substances and Disease Registry
ATV	all-terrain vehicle
BCS	biological condition score
BMI	benthic macroinvertebrate
BTAG	Biological Technical Assistance Group
CSF	Close Support Facility
DO	dissolved oxygen
DSR	data summary report
EDD	electronic data deliverable
ELI	Energy Laboratories, Inc.
EMSL	EMSL Analytical, Inc.
EPA	U.S. Environmental Protection Agency
EPH	extractable petroleum hydrocarbon
FSDS	field summary data sheets
FTL	field team leader
ft^3/sec	cubic feet per second
GO	grid opening
gpm	gallons per minute
GPS	global positioning system
HAZWOPER	Hazardous Waste Operations and Emergency Response
HQS	habitat quality score
HSI	habitat suitability index
H&S	health and safety
IL	Inter-lab
ISO	International Organization for Standardization
KDC	Kootenai Development Corporation
kg	kilogram
LA	Libby amphibole
MDC	minimal detectable concentration
MDEQ	Montana Department of Environmental Quality
MFL	million fibers per liter
mg/kg	milligrams per kilogram
mg/L	milligrams per liter
mm	millimeter
Ms/cm^2	million structures per square centimeter
Ms/g	million structures per gram
MWH	MWH Americas, Inc.
NFG	National Functional Guidelines
ND	non-detect

NIST	National Institute of Standards and Technology
NTU	nephelometric turbidity units
NVLAP	National Voluntary Laboratory Accreditation Program
ORP	oxidation reduction potential
OSHA	Occupational Safety and Health Administration
OU	operable unit
OU3	Operable Unit 3
PAH	polycyclic aromatic hydrocarbon
PCB	polychlorinated biphenyl
PCM	phase contrast microscopy
PCME	phase contrast microscopy-equivalent
PE	performance evaluation
PERL	Parametrix Environmental Research Laboratory
PLM	polarized light microscopy
PLM-VE	polarized light microscopy, visual area estimation
PLM-Grav	polarized light microscopy, gravimetric
PQL	practical quantitation limit
QA	quality assurance
QAPP	quality assurance project plan
QC	quality control
QATS	Quality Assurance Technical Support
RBP	rapid bioassessment protocol
RI	remedial investigation
RI/FS	remedial investigation/feasibility study
ROM	Record of Modification
RS	Recount Same
RD	Recount Different
SAP	sampling and analysis plan
SOP	standard operating procedure
SRMs	standard reference materials
SVOC	semi-volatile organic compound
TEM	transmission electron microscopy
TOC	total organic carbon
TPH	total purgeable hydrocarbons
µg/L	micrograms per liter
µm	micrometer
USFS	U.S. Forest Service
UV	ultraviolet
VOC	volatile organic compound

1 Introduction

1.1 Project Background

Libby is a community in northwestern Montana that is located 7 miles southwest of a vermiculite mine that operated from the 1920s until 1990. The mine began limited operations in the 1920s and was operated on a larger scale by the W.R. Grace Company (Grace) from approximately 1963 to 1990. Vermiculite from the mine contains a form of asbestos referred to as Libby amphibole (LA). This site is of potential concern to the U.S. Environmental Protection Agency (EPA) primarily because historic mining, milling, and processing of vermiculite at the site are known to have caused releases of LA to the environment, and inhalation exposure to asbestos is known to increase the risk of cancer and non-cancer effects in humans (Agency for Toxic Substances and Disease Registry [ATSDR] 2001).

Epidemiological studies revealed that workers at the mine had an increased risk of developing asbestos-related lung disease (McDonald *et al.* 1986, 2004; Amandus and Wheeler 1987; Amandus *et al.* 1987; Whitehouse 2004; Sullivan 2007). Additionally, radiographic abnormalities were observed in 17.8 percent (%) of the general population of Libby including former workers, family members of workers, and individuals with no specific pathway of exposure (Peipins *et al.* 2003; Whitehouse *et al.* 2008; Antao *et al.* 2012; Larson *et al.* 2010, 2012a, 2012b). Although the mine has ceased operations, historic or continuing releases of LA from mine-related materials could be serving as a source of ongoing exposure and risk to current and future residents and workers in the area. Based primarily on these concerns, the EPA listed the Libby Asbestos Superfund Site (Site) on the National Priorities List in October 2002.

Given the size and complexity of the Site, the EPA divided the site into eight operable units (OUs). Operable Unit 3 (OU3) includes the property in and around the former vermiculite mine and the geographic area surrounding the mine that has been impacted by releases and subsequent migration of hazardous substances and/or pollutants or contaminants from the mine (see **Figure 1-1**).

Kootenai Development Corporation (KDC), a subsidiary of W.R. Grace & Co., owns the mine and land surrounding the mine. The EPA has entered into an Administrative Order on Consent (AOC) with Respondents W.R. Grace & Co.-Conn. and KDC. The designated Project Coordinator for Respondents W.R. Grace & Co.-Conn. and KDC is Remedium Group, Inc. Under the terms of the AOC, Respondents W.R. Grace & Co. - Conn. and KDC are performing a remedial investigation (RI) in OU3, under EPA oversight, in order to characterize the nature and extent of environmental contamination and to collect data to allow the EPA to evaluate risks to humans and ecological receptors from mining-related contaminants in the environment.

1.2 Overview of OU3 Sampling Activities

Sampling in support of the OU3 RI is being performed in several phases. Sampling and analysis activities performed as part of each phase are conducted in accordance with phase-specific sampling and analysis plans (SAPs) and quality assurance project plans (QAPPs).

Phase I of the RI was performed in the fall of 2007 in accordance with the *Phase I Sampling and Analysis Plan for Operable Unit 3* (EPA 2007). The primary goal of the Phase I investigation was to obtain preliminary data on the levels and spatial distribution of LA and non-asbestos chemicals that might have been released to the environment in the past as a consequence of the mining and milling activities at the Site.

Phase II of the RI was performed in the spring, summer, and fall of 2008. Phase II was composed of three parts, as follows:

- Part A (EPA 2008a) focused on the collection of data on the levels of LA and non-asbestos chemicals in surface water and sediment, as well as site-specific toxicity testing of surface water using rainbow trout.

- Part B (EPA 2008b) focused on the collection of data on LA levels in ambient air samples collected near the mined area, and on the collection of data on LA and non-asbestos chemicals in groundwater.

- Part C (EPA 2008c) primarily focused on the collection of aquatic habitat and community data and site-specific toxicity tests to support the ecological risk assessment at the Site. This SAP also included the collection of data on the levels of LA and non-asbestos chemicals in surface water and sediment at selected reference stations.

Phase III of the RI was performed in the spring, summer, and fall of 2009 in accordance with the *Phase III Sampling and Analysis Plan for Operable Unit 3* (EPA 2009a). Phase III included the collection of activity-based air samples during simulated recreational visitor activities in the forested area, as well as the collection of a variety of ecological community and habitat metrics in support of the ecological risk assessment.

Phase IV of the RI was performed in 2010 and 2011. Phase IV was composed of two parts, as follows:

- Part A of the Phase IV SAP (EPA 2010a) was performed in the summer and fall of 2010. Part A focused on the collection of additional activity-based air samples during simulated recreational visitor, wood harvesting, forest management, and firefighting activities to support the human health risk assessment.

- Part B of the Phase IV SAP (EPA 2011a) was performed in the spring, summer, and early fall of 2011. Part B focused on the collection of additional data on LA levels in surface

water to support the ecological risk assessment. Data collection efforts also included sampling to better characterize the habitat suitability of site streams for fish.

Phase V of the RI was performed in 2012. Part A of this sampling program (EPA 2012a) included the collection of LA levels in surface water, sediment, and activity-based air samples during simulated recreational visitor activities on the Kootenai River. Part B of this sampling program (EPA 2012b) included a series of ecological studies to support the ecological risk assessment, including an amphibian toxicity test, an amphibian field assessment, in-stream caged fish studies, a resident fish lesion study, and a fish tissue burden assessment. Activity-based air samples were collected in September 2012 during authentic commercial logging activities (EPA 2012c) to support the human health risk assessment.

1.3 Document Purpose and Organization

As noted above, this document is a data summary report (DSR) for OU3 that presents results from sampling efforts conducted between 2007 and 2011 (Phase I through Phase V). An overview of sampling activities conducted from 2007 to 2011 for OU3 is provided in **Table 1-1**. Data collected in 2012 (e.g., Phase V, commercial logging) will be summarized in an update to this DSR. Although portions of these results have been presented previously as part of the Phase II, III, and IV SAPs, this document provides a summary of all results in a single comprehensive report. This document is only intended to summarize the results of each sampling program; the interpretation of these results or an evaluation of data adequacy to support risk management decision-making is beyond the scope of this report.

In addition to this introduction, this report is organized into the following sections:

Section 2 – Surface Water

Section 3 – Sediment

Section 4 – Groundwater

Section 5 – Soil and Mine Waste from the Mined Area

Section 6 – Soil, Duff Material, and Tree Bark from the Forested Area

Section 8 – Ambient Air

Section 9 – Activity-Based Sampling (ABS) Air

Section 10 – Aquatic Toxicity Tests

Section 11 – Aquatic Habitat and Community Surveys

Section 12 – Small Mammal Surveys

Section 13 – Quality Assurance/Quality Control

Section 14 – References

All tables and figures cited in the text are provided at the end of the report. Appendices are provided electronically.

2 Surface Water

Surface water samples were collected at OU3 as part of the Phase I, Phase II (Part A), Phase IV (Part B), and Phase V sampling programs. Surface water samples were analyzed for a broad suite of analytes, including LA and non-asbestos chemicals. The following sections summarize the surface water field data for each sampling program conducted between 2007 and 2012. Detailed summaries of results for asbestos and for non-asbestos chemicals in surface water samples are provided in **Appendix B** and **Appendix C,** respectively.

2.1 Phase I (2007)

2.1.1 Sampling Design

The objective of the Phase I sampling program was to collect surface water data to obtain a preliminary characterization of the nature and extent of potential surface water contamination related to historical mining, milling/processing, and mine-waste disposal operations. In addition, the Phase I sampling program also conducted a visual survey to identify and sample any springs where groundwater discharge was present and any seeps emanating from mine waste disposal areas.

Figure 2-1 identifies the locations where surface water samples were collected in Phase I. Station identifiers are summarized in **Table 2-1**. All surface water samples were collected in October 2007. All surface water samples were analyzed for LA, metals/metalloids, petroleum hydrocarbons, anions, and other water quality parameters. In addition, a broad suite of analyses were performed for samples collected at two locations: the tailings impoundment toe drain (TP-TOE1) and lower Rainy Creek downstream of the confluence with Carney Creek (LRC-2). These locations were selected because they appeared to have the best potential of characterizing releases from the mine. The additional analyses for surface water included polychlorinated biphenyls (PCBs), pesticides, herbicides, gross alpha/gross beta, volatile organic compounds (VOCs), semi-volatile organic compounds (SVOCs), polycyclic aromatic hydrocarbons (PAHs), and cyanide. At the time of sample collection, field measurements of several water quality metrics, including temperature, pH, specific conductance, dissolved oxygen (DO), oxidation/reduction potential (ORP), turbidity, and stream discharge, were measured using portable field meters.

All surface water sampling was conducted by MWH Americas, Inc. (MWH) (a contractor to Remedium Group, Inc.). Detailed information on the Phase I field sampling effort, including all associated field documentation, is provided in the *Phase I Field Sampling Summary Report* (MWH 2007).

After water samples were collected in the field, the samples for asbestos analysis were hand-delivered to the EMSL Mobile Laboratory in Libby (which is staffed by EMSL Analytical, Inc. [EMSL], a contractor to Remedium Group, Inc.) for filtration. (Note: No treatment of the water was performed prior to the filtration.) The resulting filters were analyzed for total LA by

transmission electron microscopy (TEM). Filters were prepared and analyzed using EPA Method 100.2 (EPA 1994), with modified counting procedures as described in Libby Laboratory Modification #LB-000020.

Analyses of non-asbestos chemicals in surface water were performed by Energy Laboratories, Inc. (ELI) in Billings, Montana (a contractor to Remedium Group, Inc.).

Detailed analytical results for all Phase I surface water samples (asbestos and non-asbestos) and field-collected water quality metrics are provided in the OU3 master project database (see **Appendix A**). The following sections summarize these results.

2.1.2 Non-Asbestos Results

Table 2-2 presents summary statistics on the detection frequency and concentration of non-asbestos analytes detected in water samples analyzed as part of the Phase I sampling program. As seen, a number of inorganic constituents (metals, anions, and nitrogen compounds) were detected in water, as were several indicators of petroleum hydrocarbons; but no VOCs, SVOCs, PCBs, or PAHs were detected. Metals were detected more frequently and at higher concentrations in seeps than in other surface water reaches. Additionally, several metals, including chromium, lead, nickel, vanadium, and zinc were reported as detected only in seep samples. Petroleum hydrocarbons were detected in locations within the Fleetwood Creek reach and in two seeps (CCS-1 and CCS-14). Benzene was detected in only one seep (CSS-14).

2.1.3 Asbestos Results

Table 2-3 summarizes the results of the analysis of surface water (and seeps) for LA (based on total[1] structures and structures longer than 10 micrometers [µm]). Water concentrations are expressed in terms of million fibers per liter (MFL). As seen, detected concentrations of total LA ranged widely (more than three orders of magnitude), from less than 0.1 to 125 MFL.

Figure 2-2 is a map that displays the spatial pattern of total LA results in surface water. The highest levels were observed in samples located in ponds or impoundments, including the tailings impoundment, the Mill Pond, and the pond on Fleetwood Creek, as well as from several seeps along the south side of the mined area. Levels in lower Rainy Creek (below the Mill Pond) tended to be relatively low. A sample collected just upstream of the confluence of Rainy Creek and the Kootenai River (LRC-6) was non-detect.

2.1.4 Field Measurement Results

Field data measurements collected at surface water locations sampled during the Phase I study included temperature, pH, specific conductance, DO, ORP, and turbidity. **Table 2-4** summarizes field data measurements for surface water. Temperature varied by only a few degrees at stations within stream reaches. Additionally, pH did not vary significantly within each stream reach; the lowest pH was measured in Carney Creek and the highest pH was observed in lower

[1] This includes LA structures 0.5 µm and longer with an aspect ratio (length:width) of 3:1 or greater.

Rainy Creek. At most locations, DO concentrations were below 14 mg/L; surprisingly, DO was above 20 mg/L at three of the seep locations. Turbidity was generally higher in the pond and seep samples than in stream samples.

Table 2-5 presents stream discharge measurements collected at a number of stations in the Rainy Creek watershed. As seen, flows were generally low (usually less than about 0.2 cubic feet per second [ft^3/sec]), especially in Fleetwood Creek, Carney Creek, and the upper reaches of Rainy Creek. Flows in the lower reach of Rainy Creek were slightly higher, with an average flow rate of 0.5 ft^3/sec.

2.2 Phase II, Part A (Spring-Fall 2008)

2.2.1 Sampling Design

Data from Phase I sampling program provided information on the concentrations of LA and other non-asbestos chemicals in surface water for a single sampling event (in October 2007). Because concentrations of contaminants in surface water may vary over time, especially in cases where there are large fluctuations in flow (e.g., during spring runoff), the objective of the Phase II Part A sampling program was to collect additional data to characterize the temporal and spatial patterns of LA and non-asbestos chemicals in surface water at OU3.

The Phase II Part A sampling program consisted of two monitoring efforts – one for the Rainy Creek watershed and one for the Kootenai River. Stations included in the Phase II Part A sampling program are identified in **Table 2-6**. The Rainy Creek watershed monitoring effort was split into several "elements" as follows:

> *Element 1: Seasonal Monitoring* – The purpose of this element was to measure stream flow and contaminant concentrations of LA and non-asbestos chemicals in surface water at the stations sampled in Phase I to characterize levels during spring and summer flow conditions. Four additional sampling locations – UTP, TP-Overflow, URC-1A, and CC-Pond – were also sampled (see **Figure 2-3**). Two rounds of sampling were completed – one in June 2008 and one in September 2008. All surface water samples were analyzed for LA, metals/metalloids, petroleum hydrocarbons, anions, and other water quality parameters. In addition, a broad suite of analyses were performed for samples collected at the tailings impoundment toe drain (TP-TOE1) and lower Rainy Creek downstream of the confluence with Carney Creek (LRC-2). As noted previously, these locations were selected because they appeared to have the best potential of characterizing releases from the mine. The additional analyses for surface water include PCBs, pesticides, herbicides, gross alpha/gross beta, VOCs, SVOCs, and cyanide. At the time of sample collection, field measurements of several water quality metrics, including temperature, pH, specific conductance, DO, ORP, turbidity, and stream discharge, were measured using portable field meters.
>
> *Element 2: Spring Runoff Monitoring* – The purpose of this element was to monitor stream flow and surface water LA concentrations at selected stations within the Rainy Creek

watershed during the rising and falling limbs of the spring snowmelt-runoff hydrograph. **Figure 2-4** identifies the stations that were sampled as part of Element 2. Surface water samples were collected weekly at each station beginning at the onset of rising stream flows in response to snowmelt, continuing through the spring high-flow season, and ending after the seasonal peak in flow is observed on Rainy Creek (from early April through mid-June 2008). All surface water samples were analyzed for LA. At the time of sample collection, stream flow was measured.

Element 3: Summer and Fall Monitoring – The purpose of this element was to provide on-going information on LA concentrations and stream flow rates downstream of asbestos sources within the Rainy Creek watershed. Two lower Rainy Creek stations were sampled as part of Element 3 - the station below Carney Creek (LRC-2) and the station near its discharge to the Kootenai River (LRC-6). Surface water samples were collected every two weeks at each station, beginning in mid-June and ending in mid-August 2008. All surface water samples were analyzed for LA. At the time of sample collection, stream flow was measured.

Element 4: Continuous Precipitation and Flow Monitoring – The purpose of this element was to collect continuous data on precipitation and stream flow. To accomplish this, a rain gauge was placed at the meteorological station on the mine site and permanent flumes were installed at LRC-2, LRC-6, and CC-2.

Element 5: Collection of Surface Water for Toxicity Testing – The purpose of this element was to collect site surface water for use in site-specific toxicity tests. This element is discussed further in Section 9.1.

The Phase II Part A sampling program also collected surface water samples in the Kootenai River. **Figure 2-5** provides a map of the surface water sampling locations in the Kootenai River. These locations were selected to provide surface water LA concentrations upstream and downstream of Rainy Creek and to include river locations with the greatest potential for elevated LA concentrations due to transport via Rainy Creek. Although the planned study included sampling during both high flow and low flow conditions, due to safety concerns for sampling personnel during high flow, samples were only collected under low flow conditions. All surface water samples were analyzed for LA.

All surface water sampling was conducted by MWH. Detailed information on the Phase II Part A field sampling effort, including all associated field documentation, is provided in the *Phase II Field Sampling Summary Report* (MWH 2009).

After water samples were collected in the field, the samples for asbestos analysis were hand-delivered to the EMSL Libby Mobile laboratory for filtration (Note: No treatment of the water was performed prior to the filtration). The resulting filters were then sent to EMSL in Libby, Montana, Cinnaminson, New Jersey, and Beltsville, Maryland, and Hygeia for analysis of total LA by TEM. Filters were prepared and analyzed in basic accordance with the International

Organization for Standardization (ISO) method 10312:1995(E) (ISO 1995) counting protocols, with all applicable Libby site-specific laboratory modifications.

Analyses of non-asbestos chemicals in surface water were performed by ELI.

Detailed analytical results for all Phase II Part A surface water samples (asbestos and non-asbestos) and field-collected water quality metrics are provided in the OU3 master project database (see **Appendix A**). The following sections summarize these results.

2.2.2 Non-Asbestos Results

Table 2-7 presents summary statistics on the detection frequency and concentration of non-asbestos analytes detected in water samples analyzed as part of the Phase II Part A sampling program. As seen, a number of inorganic constituents (metals, anions, and nitrogen compounds) were detected in water, but VOCs were not detected. The only hydrocarbon detected was total extractable hydrocarbon at seep CCS-8 in the June 2008 sampling event. At the two locations (TP-TOE1 and LRC-2) analyzed for the broader suite of analytes, only gross alpha and gross beta were detected.

2.2.3 Asbestos Results

Tables 2-8 through **2-11** summarize LA surface water concentrations (based on both total structures and structures longer than 10 μm) for the Phase II Part A sampling program for each element, respectively.

Element 1. Table 2-8 summarizes the LA results for surface water (and seeps) sampled in June and September as part of Element 1. As seen, detected concentrations of total LA ranged widely (more than four orders of magnitude), from 0.1 to over 1,000 MFL. The highest levels were observed in samples located in ponds or impoundments, including the pond on Fleetwood Creek and the tailings impoundment, as well as from several seeps along the south side of the mined area. However, it is possible that the higher levels noted in these samples could have been attributable to higher amounts of sediment in these samples as a consequence of sample collection methods. Total LA levels in upper Rainy Creek were usually non-detect. Total LA levels in lower Rainy Creek (below the Mill Pond) tended to be less than 9 MFL, with higher concentrations generally reported during the June sampling event.

Element 2. Table 2-9 summarizes LA results for the 11-week surface water sampling effort conducted as part of Element 2. The greatest fluctuation in total LA concentration was observed at the tailings impoundment, with total LA ranging from over 1,000 MFL in week 2 to about 3 MFL in week 11. In lower Rainy Creek, total LA concentrations fluctuated from one to two orders of magnitude over the 11-week period, with highest concentration and flows observed during week 7 (measured on May 19, 2008). **Figure 2-6** presents surface water flow and total LA concentration graphically for stations LRC-1, LRC-2, and LRC-6. As shown in this figure, there is a clear correlation between flow and concentration in lower Rainy Creek, when flow is high, concentration is high. **Figure 2-7** illustrates surface water flow and total LA concentrations

graphically for stations (URC-1A, URC-2) in upper Rainy Creek and station FC-2 in Fleetwood Creek. As seen, flow and LA concentrations seem to correlate at FC-2, but not at upper Rainy Creek Stations. **Figure 2-8** shows surface water flow and total LA concentrations for tailings impoundment stations, TP-TOE1 and TP-Overflow. This figure indicates that LA concentrations tend to be higher when flow rates are higher at these locations. Graphs of all stations are presented in **Appendix B**.

Element 3. Table 2-10 summarizes LA results for the eight surface water samples collected from mid-June to mid-August at LRC-2 and LRC-6 as part of Element 3. The average total LA concentration for both locations tended to be similar (about 3 MFL). **Figure 2-6** shows surface water flow and total LA concentration graphically for stations LRC-2 and LRC-6 for Element 3 and includes LRC-1 from Element 2. As seen, for LRC-1 and LRC-6 total LA concentrations appear to be higher when flow rates are higher; however, flow rates were not available for all samples making it impossible to establish an empirical relationship. Whereas total LA concentrations at LRC-2 do not correlate with flow rates and appear to level out over mid-June to mid-August.

Kootenai River. Table 2-11 summarizes LA results for surface water collected from the Kootenai River under low flow conditions (August). Total LA structures were observed in surface water collected from two of the stations located downstream of Rainy Creek, but concentrations tended to be low (≤ 0.1 MFL). The surface water sample collected upstream of Rainy Creek was non-detect.

2.2.4 Field Measurement Results

Tables 2-12 through **2-14** summarize field data measurements collected at surface water locations during each element of the Phase II Part A sampling events in 2008. Measurements were collected to evaluate spring and summer flow conditions during Element 1, spring runoff conditions during Element 2, summer and fall conditions in Element 3, and low flow (fall) conditions in the Kootenai River. Field measurements included: temperature, pH, specific conductance, DO, ORP, and turbidity. As would be expected, temperatures were lower and turbidity was higher in surface water samples collected in the spring than later in the year. Normally temperature varied by only a few degrees at stations within stream reaches during each sampling period. Generally higher temperatures were measured in the tailings impoundment and ponds. Additionally, pH did not vary significantly within each stream reach or sampling event. At most locations, DO concentrations ranged between 6 mg/L and 14 mg/L.

2.3 Phase II, Part C (Fall 2008)

2.3.1 Sampling Design

The Phase II Part C sampling program primarily focused on the collection of aquatic habitat and community data and site-specific toxicity tests needed to support the ecological risk assessment at the site. In addition, this sampling program also included the collection of surface water samples at two selected aquatic reference stations. Two of three candidate aquatic reference

stations were sampled (see **Figure 2-9**) – Noisy Creek (NSY-R1) and a tributary to Bobtail Creek (BTT-R1). BTT-R1 was sampled in preference to the other candidate aquatic reference station on Bobtail Creek (BTC-R1).

Surface water samples were collected from each aquatic reference station in October 2008. All surface water samples were analyzed for LA, metals/metalloids, water quality parameters, pesticides, herbicides, and SVOCs. At the time of sample collection, field measurements of several water quality metrics, including temperature, pH, specific conductance, DO, ORP, turbidity, and stream discharge, were measured using portable field meters.

All surface water sampling was conducted by Parametrix (a contractor to Remedium Group, Inc.). Detailed information on the Phase II Part C field sampling effort, including all associated field documentation, is provided in the *Final Data Report for the Autumn 2008 Aquatic Data Collection Program* (Parametrix 2009a).

After water samples were collected in the field, the samples for asbestos analysis were hand-delivered to the EMSL Mobile Laboratory in Libby for filtration. (Note: No treatment of the water was performed prior to the filtration.) The resulting filters were then sent to EMSL in Libby, Montana for analysis of total LA by TEM. Filters were prepared and analyzed in basic accordance with ISO 10312:1995(E) (ISO 1995) counting protocols, with all applicable Libby site-specific laboratory modifications.

Analyses of non-asbestos chemicals in surface water were performed by ELI.

Detailed analytical results for all Phase II Part C surface water samples (asbestos and non-asbestos) and field-collected water quality metrics are provided in the OU3 project database (see **Appendix A**). The following sections summarize these results.

2.3.2 Non-Asbestos Results

Table 2-15 presents a summary of non-asbestos analytes detected in water samples analyzed as part of the Phase II Part C sampling program. As seen, a number of metals were detected in water and slight differences between the two reference stations were observed. Dissolved cadmium was detected at NSY-R1 but not at BTT-R1. Pesticides, herbicides, and SVOCs were not detected above reporting limits at either location.

2.3.3 Asbestos Results

Table 2-16 summarizes the total LA surface water results for the aquatic reference stations. As seen, total LA was not detected in surface water samples from reference areas.

2.3.4 Field Measurement Results

Table 2-17 presents field data measurements for aquatic reference stations collected during the Phase II Part C sampling event. Field measurements included: temperature, pH, specific conductance, DO, and ORP. There appear to be some differences in reference station water

characteristics based on the limited set of field measurements. Temperature was higher at BBT-R1 and conductivity was about 25 percent lower than the value measured at NSY-R1. However, DO was similar at both stations and was about 11 mg/L. pH was not measured at NSY-R1 due to an instrument malfunction, pH at BTT-R1 was about 8.

2.4 Phase IV, Part B (2011)

Part B of Phase IV focused on the collection of additional site surface water data needed to support the ecological risk assessment. Data collection efforts included sampling and analysis of site surface waters to characterize temporal LA concentrations, as well as efforts to better characterize the habitat suitability of site streams for fish.

2.4.1 Sampling Design

Because surface water samples collected as part of the Phase I and Phase II sampling investigations may have been influenced by fibers clumping and adhering to sampling container walls, asbestos concentration values observed in these samples are uncertain. The objective of the Phase IV Part B sampling program was to collect additional surface water data to better characterize temporal LA concentrations in surface water at the OU3 site using ozonation/ultraviolet (UV) light treatment prior to filtration to address potential fiber clumping/wall adherence issues (EPA 2011a).

The Phase IV Part B sampling program consisted of regular monitoring of LA concentrations in surface water at a subset of sampling locations. This included locations where permanent flumes had been placed, including two stations in Rainy Creek (LRC-2 and LRC-6) and one station in Carney Creek (CC-2), and at the tailings impoundment (TP) (see **Figure 2-3**). These stations were selected because Lower Rainy Creek is the chief reach of concern for fish, and these stations are downstream of potential primary sources of asbestos, including the tailings disposal area (LRC-2), sediments deposited along lower Rainy Creek (LRC-6), and site seeps and ponds (CC-2). Station TP (in the tailings impoundment) was selected because it is representative of waters to which amphibians may be exposed. In order to characterize the levels of LA in surface water as a function of flow, time (season), and location, weekly sampling was conducted from mid-April (prior to the onset of rising stream flows in response to snowmelt) to July 2011 at each station, followed by bi-weekly sampling after spring flows decreased through the end of September 2011.

Whenever grab samples of surface water were collected, the in-stream temperature, pH, specific conductance, DO, ORP, and turbidity were also measured using portable field meters. In addition, continuous flow monitoring was performed at LRC-2, LRC-6, and CC-2.

All surface water sampling was conducted by MWH. A detailed report, providing all the field information and documentation for the Phase IV Part B field sampling effort has not been prepared.

After water samples were collected in the field, the samples for asbestos analysis were hand-delivered to the EMSL Mobile Laboratory in Libby for treatment (ozonation/UV light) and sonication in accordance with the procedures in EPA Method 100.1 prior to filtration. The resulting filters were then analyzed at the Mobile Laboratory or sent to EMSL in Denver, Colorado, ESAT Region 8, and Hygeia for analysis of total LA by TEM. Filters were analyzed in basic accordance with the ISO 10312:1995(E) (ISO 1995) counting protocols, with all applicable Libby site-specific laboratory modifications.

2.4.2 Asbestos Results

Table 2-18 summarizes the results of the Phase IV Part B analysis of surface water for total LA and LA greater than 10 µm in length. As seen, LA was detected in all but one sample and values ranged widely, up to 276 MFL. The highest concentrations of LA in surface water were in samples from lower Rainy Creek and were observed in the May sampling events when flows were highest. Concentrations of LA greater than 10 µm in length was detected in all but three samples and values ranged up to 55 MFL.

Figure 2-10 displays the temporal distribution of LA results along with flow measurements (for LRC-2, LRC-6, and CC-2). As seen, LA concentrations are higher when flow rates are higher and the highest flow rates were measured in May. However, some exceptions are noted, for example at LRC-2, LA concentrations increased in late July and August, but no corresponding increase in flow was noted. Additionally the elevated LA concentration observed at CC-2 on September 20, 2011 prompted the collection of an opportunistic sample on November 9, 2011. As seen on **Figure 2-10** and in **Table 2-18** LA concentrations in surface water at CC-2 in November were significantly lower than in September.

2.4.3 Field Measurement Results

Table 2-19 summarizes field data measurements collected at surface water locations sampled during the Phase IV Part B which include: temperature, pH, specific conductance, DO, ORP, and turbidity. Temperature data shows a clear temporal trend for all stations, with cooler temperatures in the spring and peaks during the hottest summer months; pH did not vary significantly within each stream reach or sampling event. At most locations, DO concentrations were below 6 mg/L. For CC-2 and LRC-6, turbidity was generally highest in the spring.

3 Sediment

Sediment samples were collected at OU3 as part of the Phase I and Phase II sampling programs. Sediment samples were analyzed for a broad suite of analytes, including LA and non-asbestos chemicals. The following sections summarize the sediment field data for each sampling program conducted between 2007 and 2010. Detailed summaries of results for asbestos and for non-asbestos chemicals in sediment samples are provided in **Appendix B** and **Appendix C,** respectively.

3.1 Phase I (2007)

3.1.1 Sampling Design

The objective of the Phase I sampling program was to collect sediment data to obtain a preliminary characterization of the nature and extent of potential sediment contamination related to historical mining, milling/processing, and mine-waste disposal operations.

Figure 2-1 identifies the locations where sediment samples were collected; these samples were co-located with the surface water samples (a description of these stations is summarized in **Table 2-1**). All sediment samples were collected in October 2007. Samples were analyzed for LA, metals/metalloids, petroleum hydrocarbons, anions, and other sediment quality parameters. A broad suite of additional analyses, including PCBs, pesticides, herbicides, VOCs, SVOCs, and PAHs, were performed for sediment samples collected from TP-TOE2 and LRC-2. As noted previously, these locations were selected because they appear to have the best potential of characterizing releases from the mine.

All sediment sampling was conducted by MWH. Detailed information on the Phase I field sampling effort, including all associated field documentation, is provided in the *Phase I Field Sampling Summary Report* (MWH 2007).

After sediment samples were collected in the field, the samples for asbestos analysis were sent to the CDM Smith Close Support Facility (CSF) in Denver, Colorado for preparation. At the CSF, each sediment sample was dried and sieved through a ¼ inch screen. Particles retained on the screen (if any) are referred to as the "coarse" fraction. Particles passing through the screen are referred to as the fine fraction, and this fraction was ground by passing it through a plate grinder. The resulting material was referred to as the "fine ground" fraction. The fine ground fraction was split into four equal aliquots. One aliquot of the fine ground material and the coarse fraction material were then shipped to EMSL at Libby, Montana for analysis of LA by polarized light microscopy (PLM).

The coarse fractions were examined using stereomicroscopy, and any particles of asbestos (as confirmed by PLM) were removed and weighed in accordance with Libby-specific standard operating procedure (SOP) SRC-LIBBY-01 (referred to as "PLM-Grav"). The fine ground aliquots were analyzed using a Libby-specific PLM method using visual area estimation (referred to as "PLM-VE"), as detailed in SOP SRC-LIBBY-03. PLM-VE is a semi-quantitative

method that utilizes site-specific LA reference materials to allow assignment of fine ground samples into one of four "bins", as follows:

- Bin A (ND): non-detect
- Bin B1 (Trace): detected at levels lower than the 0.2% LA reference material
- Bin B2 (<1%): detected at levels lower than the 1% LA reference material but higher than or equal to the 0.2% LA reference material
- Bin C: LA detected at levels greater than or equal to the 1% LA reference material

Analyses of non-asbestos chemicals in sediment were performed by ELI.

Detailed analytical results for all Phase I sediment samples (asbestos and non-asbestos) are provided in the OU3 project database (see **Appendix A**). The following sections summarize these results.

3.1.2 Non-Asbestos Results

Table 3-1 presents summary statistics on the detection frequency and concentration of non-asbestos analytes detected in sediment samples analyzed as part of the Phase I sampling program. As seen, a number of metals/metalloids and anions were detected in sediment. Significant variability is observed in results for metals/metalloids. Most metals were detected at higher concentrations in samples at seep locations (specifically CCS-8). However lead and manganese were reported at concentrations an order of magnitude higher at tailing impoundment locations than at other locations. As shown, only two chemicals (methyl acetate and pyrene) included in the additional broad spectrum suite conducted for select sediment samples were detected. PCBs, pesticides, herbicides, and other SVOCs were not detected. Petroleum hydrocarbons were detected in upper Rainy Creek, the tailings impoundment, the Fleetwood Creek Pond, and at seep CCS-11. Total extractable hydrocarbons were the most frequently detected and the highest concentration was reported in the tailings impoundment.

3.1.3 Asbestos Results

Table 3-2 summarizes the results of the analysis of sediment for LA. As seen, nearly all (22 out of 24) of the sediment samples collected contained LA. In the fine ground fraction, values ranged from non-detect to 7%. In the coarse fraction, levels generally ranged from non-detect to 0.005%. The highest percentages of LA reported in sediment samples were from seep locations, followed by samples from Carney Creek (CC-1) and the tailings impoundment.

Figure 3-1 shows the spatial pattern of LA in the fine fraction of sediment. As shown, LA was be detected in most samples, except those collected in the upper-most reaches of Rainy Creek and Fleetwood Creek. Concentrations of 1% or higher (Bin C) were reported for multiple locations. The highest levels observed were in samples collected from on-site seeps.

3.2 Phase II, Part A (Spring/Summer 2008)

3.2.1 Sampling Design

Data from Phase I sampling program provided information on the concentrations of LA and other non-asbestos chemicals in sediment for a single sampling event (conducted in the fall of 2007). Because concentrations of contaminants in sediment could vary over time, the objective of the Phase II Part A sampling program was to collect additional sediment data in the spring and summer of 2008 to characterize any potential temporal and spatial patterns of site-related contaminants in sediment at OU3.

Sediment sampling in the Rainy Creek watershed was conducted under "Element 1" of the Phase II Part A sampling program (see Section 2.2.1). The purpose of this element was to measure contaminants in sediment at the stations sampled in Phase I to characterize levels during spring and summer flow conditions.

This program differed from Phase I in that the tailings impoundment and each of the ponds (the Mill Pond and the ponds on Carney Creek and Fleetwood Creek) were sampled by collecting a series of grab samples rather than a single composite sample. **Figure 3-2** shows the 17 sediment sampling locations in the tailings impoundment. These sample locations were focused mainly in areas that are always or usually inundated with water, since these areas are most likely to serve as habitat for aquatic receptors. At the three other ponds (the Mill Pond and the ponds on Carney and Fleetwood Creeks), a total of 5 sediment grab samples were collected from each pond, including 3 samples from around the margins of the pond (at least 3 feet in from the edge) and 2 samples from near the center of the pond.

Two rounds of sampling were completed – one in June/July 2008 and one in September 2008. All sediment samples were analyzed for LA, metals/metalloids, petroleum hydrocarbons, anions, total organic carbon (TOC), and other sediment quality parameters. Sediments from lower Rainy Creek (LRC-1 to LRC-6) and the tailings impoundment toe drain (TP-TOE2) were analyzed for PCBs to assess the potential effects of use of oil for dust control along the adjacent road. Sediment collected from TP-TOE2 and LRC-2 was also analyzed for VOCs, SVOCs, and cyanide.

The Phase II Part A sampling program also collected sediment samples in the Kootenai River. In brief, the following samples were collected (see **Figure 3-3** for a map of sampling locations):

- Two grab samples from depositional areas located along the north bank of the Kootenai upstream of the mouth of Rainy Creek.
- Two grab samples from depositional areas located along the north bank of the Kootenai downstream of, but within a distance of 0.5-mile downstream from the mouth of Rainy Creek.
- Two locations from the large gravel bar located in the center of the river about 0.5-mile downstream from the mouth of Rainy Creek. One location was on the highest portion on the gravel bar; the other location was at the downstream point of the gravel bar.

All Kootenai River sediment samples were analyzed for LA.

All sediment sampling was conducted by MWH. Detailed information on the Phase II Part A field sampling effort, including all associated field documentation, is provided in the *Phase II Field Sampling Summary Report* (MWH 2009).

After sediment samples were collected in the field, the samples for asbestos analysis were sent to the CDM CSF in Denver, Colorado for preparation. After preparation, samples were sent to EMSL at Cinnaminson, New Jersey and Hygeia for analysis of LA by PLM-VE (and PLM-Grav, if a coarse fraction was present).

Analyses of non-asbestos chemicals in sediment were performed by ELI.

Detailed analytical results for all Phase II Part A sediment samples (asbestos and non-asbestos) are provided in the OU3 project database (see **Appendix A**). The following sections summarize these results.

3.2.2 Non-Asbestos Results

Table 3-3 presents summary statistics on the detection frequency and concentration of non-asbestos analytes detected in sediment samples analyzed as part of the Phase II Part A sampling program. As seen, a number of metals/metalloids, anions, and hydrocarbons were detected in sediment in all areas in both sampling events. There is significant variability in concentrations, although temporal patterns are not obvious.

Total extractable hydrocarbons were the most frequently detected hydrocarbons and were detected in at least one sediment sample from each area, with concentrations ranging from 22 milligrams per kilogram (mg/kg) to 2,360 mg/kg. The most frequently detected carbon ranges were C11 to C22 aromatics and C19 to C36 aliphatics; these carbon ranges were detected in about 90% of the samples. PCBs were not detected in sediment samples from lower Rainy Creek and or the tailings impoundment. Sediment samples collected at TP-TOE2 and LRC-2 were also analyzed for PAHs, PCBs, VOCs, SVOCs, and cyanide. With the exception of PAHs, none of these compounds were detected in sediment. PAHs were detected at LRC-2 in Round 1 and methyl acetate was detected at both locations during Round 2. Detection limits for PAHs vary due to varying moisture content in sediment samples and the reported detections at LRC-2 were below detection limits for most other samples.

3.2.3 Asbestos Results

Table 3-4 summarizes the LA results for sediment samples collected during the Phase II Part A sampling program. LA results for the fine ground fraction of sediment samples ranged from non-detect to 5%, with concentrations of <1% or trace reported in most samples. Maximum LA concentrations were reported in sediment samples collected from seep locations. At locations sampled in upper Rainy Creek, LA concentrations were non-detect or trace for all samples.

Table 3-5 summarizes the LA results for sediment samples collected from the Kootenai River. As shown, LA results for the fine ground fraction sediment samples from the downstream Kootenai River stations ranged from non-detect to trace. The sample from the upstream station (UKR-2) was non-detect.

3.3 Phase II, Part C (Fall 2008)

3.3.1 Sampling Design

As noted previously, the Phase II Part C sampling program included the collection of environmental samples at two of the three candidate aquatic reference stations, Noisy Creek (NSY-R1) and a tributary to Bobtail Creek (BTT-R1) (see **Figure 2-9**). In addition, sediment samples were also collected from a subset of stations in Rainy Creek (URC-1A, URC-2, LRC-2, LRC-3, LRC-5, and TP-TOE2), Fleetwood Creek (FC-2), and Carney Creek (CC-2) concomitant with the collection of the aquatic community surveys (see Section 10.3) (see **Figure 2-3**). Sediment samples were collected from each station in October 2008. All sediment samples were analyzed for LA, metals/metalloids, TOC, pH, and total solids.

All sediment sampling was conducted by Parametrix (a contractor to Remedium Group, Inc.). Detailed information on the Phase II Part C field sampling effort, including all associated field documentation, is provided in the *Final Data Report for the Autumn 2008 Aquatic Data Collection Program* (Parametrix 2009a).

Detailed analytical results for all Phase II Part C sediment samples (asbestos and non-asbestos) are provided in the OU3 project database (see **Appendix A**). The following sections summarize these results.

3.3.2 Non-Asbestos Results

Table 3-6 presents summary statistics on the detection frequency and concentration of non-asbestos analytes detected in sediment samples analyzed as part of the Phase II Part C sampling program. As seen, a number of metals/metalloids were detected in sediment. There was significant variability in the results for Rainy Creek, Fleetwood Creek, and Carney Creek; however, concentrations of metals/metalloids in sediments from the aquatic reference stations were generally similar.

3.3.3 Asbestos Results

Table 3-7 summarizes the LA results for sediment samples collected during the Phase II Part C sampling program. As seen, LA levels ranged from non-detect to 5% in the fine ground fraction and from non-detect to 10.6% in the coarse fraction. **Figure 3-4** shows the spatial distribution of LA concentrations observed in the Phase II Part C sampling program. LA was not detected in sediment from the off-site reference locations or at the furthest upstream location in upper Rainy Creek. Trace amounts of LA were reported in upper Rainy Creek and in Fleetwood Creek. Generally the highest levels observed were in samples collected from Carney Creek.

4 Groundwater

Groundwater samples were collected at OU3 as part of the Phase II Part B sampling program. Three rounds of sampling were completed for groundwater, occurring in the summer and fall of 2008, and the spring of 2009. Groundwater samples were analyzed for a broad suite of analytes, including LA and non-asbestos chemicals. The following sections summarize the groundwater data collected at OU3 during these sampling efforts. Detailed summaries of results for asbestos and for non-asbestos chemicals in groundwater samples are provided in **Appendix B** and **Appendix C,** respectively.

4.1 Sampling Design

A site reconnaissance effort was conducted by MWH in the fall of 2007 (during the Phase I sampling program) to identify any groundwater wells at OU3. A total of ten wells were identified within the vicinity of OU3 (see **Figure 4-1**). **Table 4-1** summarizes information for each of these wells. Five of the ten wells identified (wells A, C, D, E, and H) as agreed upon with the EPA were sampled as part of the Phase II Part B sampling program. Groundwater samples were collected from wells A, D, and E in each of three sampling events – July 2008, September 2008, and June 2009. Groundwater samples were collected from Well C in September 2008 and June 2009 and from Well H in July 2008 and June 2009. No sample was collected from Well H in September 2008 (Round 2) because the well was dry. All groundwater samples were analyzed for LA, metals/metalloids, petroleum hydrocarbons, anions and other water quality parameters, gross alpha/gross beta, and cyanide. If the total extractable petroleum hydrocarbon (EPH) concentration exceeded 300 micrograms per liter (µg/L), samples were also analyzed for specific EPH compounds (e.g., C9-C18 aliphatics, C19-C36 aliphatics, and C11-C22 aromatics) and PAHs. At the time of sample collection, field measurements of several water quality metrics, including temperature, pH, specific conductance, DO, ORP, and turbidity, were measured using portable field meters.

All groundwater sampling was conducted by MWH. Detailed information on the Phase II Part B field sampling effort conducted in 2008, including all associated field documentation, is provided in the *Phase II Field Sampling Summary Report* (MWH 2009). (Note: A field sampling summary report for groundwater sampling efforts completed in 2009 has not been prepared.)

After groundwater samples were collected in the field, the samples for asbestos analysis were hand-delivered to the EMSL Mobile Laboratory in Libby for filtration. (Note: No treatment of the water was performed prior to the filtration.) The resulting filters were analyzed by EMSL at Libby, Montana for total LA by TEM. Filters were prepared and analyzed in basic accordance with ISO 10312:1995(E) (ISO 1995) counting protocols, with all applicable Libby site-specific laboratory modifications.

Analyses of non-asbestos chemicals in groundwater were performed by ELI.

Detailed analytical results for all groundwater samples (asbestos and non-asbestos) and field-collected water quality metrics are provided in the OU3 project database (see **Appendix A**). The following sections summarize these results.

4.2 Non-asbestos Results

Table 4-2 presents summary statistics on the detection frequency and concentration of non-asbestos analytes detected in groundwater samples collected as part of the Phase II Part B sampling program. As seen, a number of inorganic constituents (metals, anions, and nitrogen compounds) were detected in groundwater in all three sampling rounds.

In general, metals were more frequently detected and at higher concentrations in Well A, a shallow groundwater well located in the Carney Creek drainage. Concentrations of nitrogen compounds varied over three orders of magnitude with the highest concentrations observed in Wells D, E, and H. Gross alpha was detected in 11 out of 13 samples and gross beta was detected in all samples, with the highest levels observed in Well E during Round 3. Petroleum hydrocarbons were detected in all wells except Well C. EPH concentrations varied by two orders of magnitude with the highest EPH concentration reported at Well H. PAHs and EPH specific compounds were not detected in any samples selected for these analyses. Toluene was the only volatile hydrocarbon detected and was detected at a concentration of less than 1 µg/L in Wells D and E in September 2008.

4.3 Asbestos Results

Table 4-3 summarizes the LA groundwater concentrations (based on total LA and LA longer than 10 µm) for each well for each sampling event. Total LA concentrations ranged from non-detect to about 65 MFL and LA concentrations for structures longer than 10 µm ranged from non-detect to about 3 MFL. LA was detected more frequently and at higher concentrations in Well E in most sampling rounds. Concentrations of LA in samples from Wells A and H were lower in the spring compared to the winter.

As noted above, collected groundwater samples were not treated (ozonation/UV) prior to filtration to address potential fiber clumping/wall adherence issues (EPA 2011a). As seen in **Table 4-3**, samples collected in Rounds 1 and 2 were not filtered until 3-5 months after sample collection; thus, asbestos concentrations in these samples are uncertain.

4.4 Field Measurement Results

Table 4-4 summarizes field data measurements collected at groundwater wells in July and September 2008 including: temperature, pH, specific conductance, DO, ORP, turbidity, the volume of water extracted, and the flow rate. Because wells are screened at different depths, field measurements vary from well to well. Of note, turbidity was quite high (greater than 2,000 nephelometric turbidity units [NTU]) in the groundwater sample from Well A collected in July 2008. However, groundwater at Well A is shallow (depth to groundwater was measured at only

3.81 feet below the top of the casing during the July 2008 event) and field samplers noted organic material in this sample. Flow rates that could be determined were low for all wells, ranging from 0.25 gallons per minute (gpm) to 0.75 gpm.

5 Soil and Mine Waste from the Mined Area

Sampling of soil and mine waste materials from the mined area was completed in October 2007 as part of the Phase I sampling program. These samples were analyzed for a broad suite of analytes, including LA and non-asbestos chemicals. The following sections summarize the field data for these samples. Detailed summaries of results for asbestos and for non-asbestos chemicals in soil and mine waste samples are provided in **Appendix B** and **Appendix C,** respectively.

5.1 Sampling Design

The objective of the mine waste sampling activities conducted as part of the Phase I program was to collect samples from representative types of waste materials and soils in the mined area in order to identify environmental contaminants associated with mine wastes and develop a list of source areas of potential concern. **Figure 5-1** shows the locations where samples of mine wastes and surface soil were collected. **Table 5-1** summarizes each type of soil and mine waste sample. In brief, samples were collected from:

- waste rock from various piles;
- cover material;
- coarse tailings disposal area;
- tailings impoundment;
- outcrops; and
- materials used for construction of unpaved sections of Rainy Creek Road.

Samples collected from the impounded tailings (MS-4 and MS-5) and the coarse tailings area (MS-6 to MS-9) were collected as an 8-point transect composite collected from the top 12 inches of material. **Figure 5-2** provides a schematic illustration of the sampling procedure for the transect samples. All other samples were collected as surficial (0-6 inches) grab samples.

All samples were analyzed for LA and metals/metalloids. Mine waste rock, tailings, soil from the former mill area, and roadway materials were also analyzed for petroleum hydrocarbons. The three samples of Rainy Creek roadway materials were analyzed for PCBs (based upon reports that oil had been used in the past to control dust on mine roads and PCB oils were present at the mine in the past). Samples collected from the fine tailings impoundment were analyzed for a broader suite of potential contaminants, including pesticides, VOCs, SVOCs (PAHs), and cyanide, as well as PCBs, petroleum hydrocarbons, anions, and other soil quality parameters.

All soil and mine waste sampling was conducted by MWH. Detailed information on the Phase I field sampling effort, including all associated field documentation, is provided in the *Phase I Field Sampling Summary Report* (MWH 2007).

After soil and mine waste samples were collected in the field, the samples for asbestos analysis were sent to the CDM Smith CSF in Denver, Colorado for preparation. After preparation,

samples were sent to EMSL at Libby, Montana and Cinnaminson, New Jersey for analysis of LA by PLM-VE (and PLM-Grav, if a coarse fraction was present). Analyses of non-asbestos chemicals in soil and mine waste were performed by ELI.

Detailed analytical results for all Phase I soil and mine waste samples (asbestos and non-asbestos) are provided in the OU3 project database (see **Appendix A**). The following sections summarize these results.

5.2 Non-Asbestos Results

Table 5-2 presents summary statistics on the detection frequency and concentration of analytes detected in soil and mine waste samples analyzed as part of the Phase I sampling program. As shown, metals/metalloids were the most frequently detected analytes. For organic chemicals, a variety of PAHs and hydrocarbons were detected in several samples, and pentachlorophenol and methyl acetate were also detected in a few samples. Results for soil and mine wastes samples are summarized below, grouped by media type.

Waste Rock Samples

Twenty-nine waste rock samples were collected and analyzed for metals/metalloids and petroleum hydrocarbons. There is substantial variability in the analytical results for metals. Metals detected in less than 5% of the samples include antimony and mercury; both of these metals were detected only in waste rock samples. Thallium was detected in only one of the waste rock samples. Petroleum hydrocarbons, mostly extractable hydrocarbons, were detected in several waste rock samples. Volatile hydrocarbons (C5 to C8 aliphatics, C9 to C10 aromatics, and toluene) were detected at MS-14. In addition, total purgeable hydrocarbons (TPH) were detected at MS-14, MS-18, and MS-28. PAHs were analyzed for, but not detected, at MS-20.

Roadway Samples

Metals, anions, and petroleum hydrocarbons were detected in the three roadway samples collected (MS-1 to MS-3). Most metals were detected at higher concentrations at MS-2. Petroleum hydrocarbons were detected in all roadway sample locations; the highest concentrations of EPH were also observed at MS-2. PCBs, PAHs, and volatile hydrocarbons were not detected in roadway samples.

Tailings Samples

Several metals and anions were detected in the six tailings samples. Most metals were detected at higher concentrations at MS-5. Thallium was detected in two of the tailings samples. One pesticide, pentachlorophenol, was detected at MS-5. Methyl acetate was the only VOC detected above reporting limits and was detected at MS-4 and MS-5. Several PAHs and EPH compounds were also detected at MS-4 and MS-5, but not at other locations. PCBs were not detected in tailings samples.

5.3 Asbestos Results

Table 5-3 summarizes the LA results for soil and mine waste samples collected during the Phase I sampling program. Asbestos levels in mine waste are shown in **Figure 5-3**.

All soil and mine waste samples collected had a coarse (> ¼-inch) fraction, which was analyzed by PLM-Grav. All coarse fractions had detectable levels of LA, with concentrations by PLM-Grav ranging from trace to 0.037%. The highest measured LA values by PLM-Grav were generally in waste rock, with 7 out of the 13 waste rock samples having LA concentrations greater than 0.01%.

PLM-VE analyses of the fine ground fraction showed that LA concentrations in the majority of samples were less than 1%. The highest levels of LA were generally measured in waste rock samples. The maximum level of LA in fine ground material (8%) was observed at outcrop location MS-25. LA concentrations greater than 1% were also measured in cover materials and coarse tailings.

6 Soil, Duff Material, and Tree Bark from the Forested Areas

The Phase I sampling program included the collection of soil, duff material (i.e., leaf litter, pine needles, organic debris), and tree bark from the forested area surrounding the mine. All samples were collected in October 2007 and analyzed for LA. In the fall of 2011, a subset of the forest soil samples collected during Phase I was subsequently analyzed for metals/metalloids.

The following sections summarize the field data for these samples. A detailed summary of results for asbestos in soil, duff material, and tree bark, are provided in **Appendix B.** A detailed summary of non-asbestos chemicals in soil is provided in **Appendix C.**

6.1 Phase I (2007)

6.1.1 Sampling Design

The objective of the Phase I forest sampling effort was to determine the potential extent and spatial pattern of releases of airborne asbestos from the mine. To facilitate a spatial pattern analysis, samples were collected along a number of transects that radiated away from the mine, with special emphasis on the predominant downwind direction (northeast). **Figure 6-1** shows the transects and locations that were sampled as part of the Phase I sampling program.

Table 6-1 describes the transects where tree bark, soil, and duff samples were collected. At each location shown in **Figure 6-1**, one Douglas fir tree (at least 8 inches in diameter) was selected for tree bark analysis. In selecting the tree for sampling, trees having rough bark were preferred over trees with smoother bark, since it was expected that rough bark would tend to capture and retain airborne asbestos fibers on the bark surface more efficiently. For each tree, a tree bark sample was collected at a height of about 4-5 feet above ground from the side of the tree facing toward the mine site using a 2-inch diameter hole saw. In addition, for about 10% of the selected trees, an increment boring device was used to collect a core sample for tree-ring analysis to determine the tree age. At each location, one 5-point composite soil sample was collected from approximately equally spaced sub-locations around the perimeter of a circle with a radius of about 5 feet, centered on the tree that was selected for bark analysis. At each soil collection sub-location, the duff material that was overlying the surface soil was also collected to determine if this organic debris layer contained a significant fraction of the historically deposited asbestos fibers.

All forest area sampling was conducted by MWH. Detailed information on the Phase I field sampling effort, including all associated field documentation, is provided in the *Phase I Field Sampling Summary Report* (MWH 2007).

All tree bark and duff samples were sent to EMSL in Libby, Montana, Cinnaminson, New Jersey, and Beltsville, Maryland for preparation and analysis for LA in accordance with SOP TREE-LIBBY-OU3 and SOP DUFF-LIBBY-OU3, respectively. In brief, samples were dried, ashed, weighed, and hand-mixed. An aliquot of the resulting ash was treated with acid, suspended in water, and filtered onto a 47-millimeter (mm) mixed cellulose ester filter with 0.4-

μm pore size. This filter was prepared and analyzed by TEM in basic accordance with ISO 10312:1995(E) (ISO 1995) with all applicable Libby site-specific laboratory modifications..

Soil samples collected in the field for asbestos analysis were sent to the CDM Smith CSF in Denver, Colorado for preparation. After preparation, samples were sent to EMSL in Libby, Montana for analysis of LA by PLM-VE (and PLM-Grav, if a coarse fraction was present). Detailed analytical results for all tree bark, soil, and duff samples are provided in the OU3 project database (see **Appendix A**). Section 6.1.2 summarizes the asbestos results for each media.

Age cores were sent to the Tree-Ring Laboratory at the University of Arizona for the estimation of tree age. Section 6.1.3 summarizes the tree age results.

Supplemental Evaluation of Metals

As noted above, in the fall of 2011, a subset of the forest soil samples collected as part of the Phase I investigation were subsequently analyzed for metals/metalloids. The purpose of this effort was to provide site-specific data on metal concentrations in soils that were thought to be representative of reference conditions (i.e., not impacted by mining activities). A total of 12 samples were selected for metals analysis. Samples were selected from the furthest two sampling locations from the distal ends of each of six transects (see **Figure 6-2**), three downwind transects (circled in white) and three cross-wind/upwind transects (circled in green). All samples were analyzed for metals/metalloids by ELI.

Detailed analytical results for all forest soil samples analyzed for metals/metalloids are provided in the OU3 project database (see Appendix A). Section 6.1.4 summarizes the metals/metalloid results for the forest soil samples.

6.1.2 Asbestos Results

Table 6-2 summarizes the total[2] LA results for each tree bark sample. In this table, results are presented as a surficial loading estimate (i.e., million LA structures per square centimeter of bark surface area [Ms/cm^2]). A map of these results is shown in **Figure 6-3**. Maximum concentrations were observed in the predominant wind direction towards the northeast. A spatial plot of total LA surface loading levels for tree bark as a function of distance from the mine is shown in **Figure 6-4**. Total LA tree bark surface loading levels ranged from non-detect to 16 Ms/cm^2. Generally, total LA levels are highest within about 4 miles of the mine. Total LA levels for tree bark samples collected 4 or more miles from the mine were less than 1 Ms/cm^2. **Figures 6-5 to 6-11** present the tree bark results in a profile view for each transect.

Table 6-3 summarizes the LA results for all forest soil samples collected during the Phase I sampling program. **Figure 6-12** shows a map of PLM-VE LA results for forest soil samples. As

[2] Total: all LA structures observed and recorded during the TEM analysis (i.e., all structures longer than 0.5 μm with an aspect ratio of 3:1 or greater).

shown, nearly all forest soil samples had a coarse fraction. Most PLM-VE and PLM-Grav results were non-detect. Trace LA concentrations were observed in 7 samples within 2 miles of the mine, 6 of which were located northeast of the mine. Three samples had LA concentrations above trace concentrations. The maximum LA concentration was reported in SL-135-01, which is located one half mile from the mine across gradient from the primary downwind direction.

Table 6-4 summarizes the total LA results for each duff sample. In this table, results for total LA are presented on a dry weight basis as million structures per gram of duff (Ms/g) and as mass percent (grams of LA per 100 grams of duff material). However, because estimates of mass percent are uncertain as a consequence of the calculation approach, reporting duff concentrations as Ms/g is preferred. **Figure 6-13** shows a map of the total LA results duff samples, expressed as Ms/g. A spatial plot of total LA concentrations in duff as a function of distance from the mine is shown in **Figure 6-14**, expressed as Ms/g. Generally, LA concentrations are higher in duff samples collected within 2 miles of the mine in all directions. Total LA in duff samples ranged in concentration from non-detect to about 3,200 Ms/g, with the majority of sample concentrations falling below 1,000 Ms/g. Total LA concentrations were greater than 1,000 Ms/g in nine samples. **Figures 6-15 to 6-19** present the duff results in a profile view.

Figure 6-20 presents a map of LA results for tree bark, soil, and duff material at each location.

6.1.3 Tree Age Results

Detailed results of the tree age assessment were presented in Sheppard (2007). **Table 6-5** summarizes the estimated tree age for all collected age cores. The twelve trees selected for this analysis ranged in age from 29 to 100 years old (average age was 69 years). The oldest trees sampled were in SL15 (about 5 miles from the Mine, 30° counter clock-wise from the approximate primary downwind direction). In **Figure 6-21**, Panel A presents the tree diameter measured in the field relative to the tree age (as determined by the age cores) and Panel B presents the measured LA surface loading level on the tree bark relative to the tree age. As shown, the age of coniferous trees in this area cannot be accurately predicted based on measured tree diameter. In addition, there does not appear to be a correlation between the age of the tree and the level of LA surface loading measured on the tree bark.

6.1.4 Metals Results

Table 6-6 presents summary statistics for metals for forest soil samples from the downwind transects and the cross-wind/upwind transects. Statistical comparisons of these two datasets were made using the two-sample hypothesis testing approach for datasets with non-detects (Gehan test) provided in ProUCL v4.00.05 (EPA 2010b). There was no statistically significant difference between samples from the downwind transects and the cross-wind/upwind transects. **Table 6-7** presents the summary statistics for metals for all forest soil samples.

7 Ambient Air

Air monitoring under ambient conditions at OU3 was completed as part of the Phase I and Phase II Part B sampling programs. Two rounds of monitoring were performed, the first occurred in the fall of 2007 and the second in the summer/fall of 2008. Ambient air samples were analyzed for LA. The following sections summarize the ambient air field data. A detailed summary of results for asbestos in ambient air is provided in **Appendix B.**

7.1 Phase I (2007)

7.1.1 Sampling Design

The objective of the Phase I sampling program was to collect data to obtain a preliminary characterization of the nature and extent of potential contamination related to historical mining, milling/processing, and mine-waste disposal operations. Because wind speed and direction are variable, eight stationary air monitors were placed in two concentric rings around the mine area to evaluate asbestos concentrations in ambient air at the mine. The first ring was placed close to the boundary of the disturbed mine area, and the second ring was close to the perimeter of the property owned by KDC. **Table 7-1** summarizes ambient air monitoring locations and **Figure 7-1** shows the locations for the ambient air monitors. Each ambient air sample was collected over a period of 5 days. A total of four sampling events were conducted from October 2 to 22, 2007.

All ambient air monitoring was conducted by MWH. Detailed information on the Phase I field sampling effort, including all associated field documentation, is provided in the *Phase I Field Sampling Summary Report* (MWH 2007).

The ambient air filters were sent to EMSL for analysis of asbestos by TEM. Filters were prepared and analyzed in basic accordance with ISO 10312:1995(E) with all applicable Libby site-specific laboratory modifications.

Detailed analytical results for all Phase I ambient air samples are provided in the OU3 project database (see **Appendix A**). The following section summarizes these results.

7.1.2 Asbestos Results

Table 7-2 presents the LA (total and phase contrast microscopy-equivalent [PCME]) air concentrations for all ambient air samples collected as part of the Phase I sampling program. All filters were able to be prepared directly for analysis by TEM. As shown, all samples were non-detect (most samples had an analytical sensitivity of about 0.0005 cc^{-1}).

7.2 Phase II, Part B (2008)

7.2.1 Sampling Design

Although all the Phase I ambient air samples were non-detect, these data were not considered to be sufficient to conclude ambient air was not of concern because they were collected during a

time of frequent rain (so the potential for release may have been reduced) and because they only spanned a time period of 20 days. Thus, additional ambient air data were collected as part of the Phase II Part B sampling program.

A total of eight stationary ambient air monitors were established around the perimeter of the mined area. The locations of these monitoring stations are shown in **Figure 7-2**. In this figure, stations A-4, A-5, A-6 and A-8 were placed at the same locations as were sampled in Phase I, while stations A-9 to A-12 were new stations. As indicated, five stations were located to the north and east of the mined area, since available meteorological data indicate that the predominant wind direction is to the northeast. Three stations were located along the southern perimeter to capture any releases that may occur during wind reversals. Each ambient air sample was collected over a period of 5 days. A total of eight sampling events were conducted from July 7 to October 17, 2008.

All ambient air monitoring was conducted by MWH. Detailed information on the Phase II Part B field sampling effort, including all associated field documentation, is provided in the *Phase II Field Sampling Summary Report* (MWH 2009).

The ambient air filters were sent to EMSL in Libby, Montana for analysis of asbestos by TEM. Filters were prepared and analyzed in basic accordance with ISO 10312:1995(E) with all applicable Libby site-specific laboratory modifications.

Detailed analytical results for all Phase II ambient air samples are provided in the OU3 project database (see **Appendix A**). The following section summarizes these results.

7.2.2 Asbestos Results

Table 7-3 presents the LA (total and PCME) air concentrations for all ambient air samples collected as part of the Phase II sampling program. All filters were able to be prepared directly for analysis by TEM. As shown, LA was detected in one or more ambient air samples at stations A-5, A-6, A-9, and A-11. Stations A-5, A-6, and A-11 are located northeast of the mine (in the predominant downwind direction). However, the highest concentration of LA in ambient air was reported at station A-9, located south of the mine.

8 Activity-Based Sampling (ABS) Air

Activity-based sampling (ABS) is a standard sampling technique that is used to measure air concentrations during disturbances of asbestos-contaminated materials. During ABS, air monitors are worn by personnel that are engaged in a variety of source disturbance activities, and the resulting air filters are analyzed for asbestos to determine the asbestos air concentration. These air concentrations can then be used to estimate exposures for the purposes of evaluating potential human health risks.

ABS air samples have been collected at OU3 as part of the Phase III and Phase IV Part A sampling programs to evaluate a variety of source disturbance scenarios. All collected ABS air samples were analyzed for LA. The following sections summarize the ABS air data from these sampling programs. A detailed summary of results for asbestos in ABS samples is provided in **Appendix B.**

8.1 Phase III (2009)

8.1.1 Sampling Design

A range of different human receptors may be exposed to LA in OU3, including trespassers or "rockhounds" in the mined area, recreational visitors in the forested area and along OU3 streams and ponds, as well as wood harvesters, U.S. Forest Service (USFS) workers, and fire fighters in the forested area.

The Phase III sampling program focused on the collection of ABS data to evaluate LA exposures to recreational visitors in the forested area during the following types of activities:

- Walking or hiking in the forest area around the mine site
- Riding an all-terrain vehicle (ATV) in the forest area around the mine site
- Sawing trees or stacking wood with potentially contaminated tree bark
- Actively disturbing soil and duff when clearing a camping area or building a fire
- Inhalation of smoke from burning wood with contaminated tree bark

A total of 20 ABS areas (see **Figure 8-1**) were identified as candidate areas for evaluation in Phase III. These areas were selected based primarily on a consideration of the large-scale spatial variability of measured LA levels in forest soil, duff, and tree bark (see Section 6), as well as inspection of available maps on roads, trails, and terrain in OU3. Eleven of these areas (shaded in yellow in **Figure 8-1**), those that tended to be predominately in the downwind direction (north-northeast of the mine), were selected for ABS evaluation.

For each ABS area, two ABS personnel performed the following scripted activities:

ABS Sample	Time (minutes)		Person	
	Start	Stop	No. 1	No. 2
A	0	20	ATV (lead)	ATV (follow)
	20	40	ATV (follow)	ATV (lead)
B	40	60	Hike (lead)	Hike (follow)
	60	80	Hike (follow)	Hike (lead)
C	80	100	Saw	Pile wood
	100	120	Pile wood	Saw
	120	140	Rake	Rake
	140	150	Dig	Dig
	150	180	Build and stand near campfire [a]	

[a] For safety reasons, this activity did not occur in the ABS area, but was conducted on W.R. Grace-owned property near Rainy Creek Road and Highway 37 (the area formerly known as the Flyway) using the wood collected from the ABS area.

As shown, a set of three ABS samples (A, B, and C) were generated for each person. Only one set of ABS samples was submitted for analysis, the other set was archived. ABS events were conducted at each area approximately every 10 days, starting at the end of August through the beginning of November 2009.

All ABS was conducted by MWH. Detailed information on the Phase III field sampling effort, including all associated field documentation, is provided in the *Phase III Activity-Based Sampling Summary Report* (MWH 2010).

The ABS air filters were sent to Hygeia Laboratories, Inc. for analysis of LA by TEM. Filters were prepared and analyzed in basic accordance with ISO 10312:1995(E), with all applicable Libby site-specific laboratory modifications, including the most recent versions of modifications LB-000016, LB-000019, LB-00028, LB-000030, LB-000053, LB-000066, and LB-000085.

Detailed analytical results for all Phase III ABS air samples are provided in the OU3 project database (see **Appendix A**). The following section summarizes these results.

8.1.2 Asbestos Results

Table 8-1 presents the detection frequency and summary statistics for total and PCME LA in ABS air for each activity (ATV riding, hiking, fire building/burning) stratified by ABS area. As shown, 6 to 8 sampling rounds were conducted for each ABS area. All ABS samples were able to be prepared directly, and all samples achieved the target analytical sensitivity of 0.0060 cc^{-1}.

The mean concentration of total LA varied over an order of magnitude depending on the ABS area and the activity performed (see **Figure 8-2**). LA was more frequently detected and at higher concentrations for individuals involved in fire building/burning. Clear spatial patterns are not apparent, but there is a general tendency for air samples from ABS areas located 6-8 miles from the mine to be lower than air samples from ABS areas located closer to the mine.

For the ATV riding scenario, LA was detected most frequently in ABS samples collected in ABS-10, an area located within 2 miles of the mine, where elevated levels of LA in tree bark and duff material were measured in the Phase I investigation. However, detected LA was also reported in some ABS air samples collected in areas farthest from the mine, though at a lower frequency. LA was not detected in ABS samples in areas ABS-01, ABS-02, ABS-05, ABS-06, and ABS-13.

For the hiking scenario, LA was detected most frequently and at higher concentrations in area ABS-13. The frequency of detection tended to be lowest in ABS areas located furthest from the mine. LA was not detected in ABS samples in areas ABS-01 and ABS-08.

For the fire building/burning scenario, LA was detected in one or more samples for all but one ABS area (ABS-14), which happened to be located closest to the mine. In general, the fire building/burning scenario resulted in higher air concentrations than the other two ABS scenarios.

8.2 Phase IV, Part A (2010)

8.2.1 Sampling Design

The Phase IV Part A sampling program focused on the collection of ABS data to evaluate LA exposures to recreational visitors along OU3 streams and ponds, residential wood harvesters, USFS workers, and fire fighters in the forested area (under synthetic fire-fighting conditions). In addition, the Phase IV Part A SAP included a plan for the collection of opportunistic air samples during authentic forest fires in OU3. For the purposes of the Phase IV Part A ABS effort, only a subset of the 11 ABS areas evaluated in the Phase III study were sampled. For most ABS scenarios evaluated in the Phase IV Part A effort, three ABS areas were selected to represent locations "near" (ABS-10), "middle" (ABS-07), and "far" (ABS-02) from the mine (see **Figure 8-3**).

ABS activities were separated into 6 different "scripts" as follows:

> *Script 1.* This script was designed to simulate recreational visitor exposures while hiking along lower Rainy Creek between Highway 37 and the W.R. Grace property line (see the "LRC Study Area" in **Figure 8-3**). In this script, two ABS personnel walked up along the banks of the creek, disturbing bushes and other vegetation as needed to move along the bank of the creek. Personnel switched positions (leader/follower) after half of the sampling time has elapsed. A total of 5 sampling events were conducted in August 2010.
>
> *Script 2.* This script was designed to simulate exposures during non-commercial (e.g., residential) wood harvesting activities in the forested area in OU3. The script included two types of activity – 2A) driving to and from the wood harvesting area, and 2B[3]) felling, limbing, cutting, and stacking harvested wood. Two ABS personnel performed

[3] After the first round of sampling, this script was split into two parts (2B.1 - felling & limbing activities; 2B.2 - cutting & stacking activities) and, in some cases, script 2B.2 was split across two different filters (filter 'a' and 'b'), to reduce the potential for filter overloading and need for indirect preparation.

the scripted activities in each ABS area during each sampling event. ABS was conducted in ABS-02, ABS-07, and ABS-10 (see **Figure 8-3**). A total of 5 sampling events were conducted in each ABS area between July and August 2010.

Script 3. The first part of this script (3A, 3B, 3C) was designed to simulate exposures to USFS workers during activities routinely performed as part of the USFS land management responsibilities. The script included three types of activities – 3A) maintenance of roads and trails, 3B) thinning of trees and vegetation, and 3C) surveying trees (i.e., stand examination). The second part of this script (3D, 3E) was designed to simulate exposures to USFS workers during fire-fighting activities. The script included two types of activities – 3D) cutting fire lines by hand using a Pulaski tool, and 3E) cutting fire lines using heavy equipment (e.g., a bulldozer or tractor plow). Two ABS personnel performed the scripted activities in each ABS area during each sampling event. ABS was conducted in ABS-02, ABS-07, and ABS-10 (see **Figure 8-3**). A total of 5 sampling events were conducted in each ABS area between July and August 2010.

Script 4. This script was designed to simulate exposures to ground-based fire fighters from LA in air released by burning of contaminated duff and trees in OU3. Personal and stationary air samples were to be collected during a simulated forest fire, which was to be achieved by the burning two large slash piles in OU3 (see **Figure 8-3** for slash pile locations). However, due to safety concerns, this script was not performed.

Script 5. This script was designed to provide data on exposures to aircraft pilots during fire suppression flights from LA in air released by burning of contaminated duff and trees in OU3. Script 5A was intended to collect data during a simulated forest fire (i.e., the slash pile burn). Script 5B was designed to collect opportunistic samples during authentic forest fires in OU3, by placing an air monitor in the cockpit of responding aircraft. As noted above, the slash pile burn was not conducted and no wildfires have occurred in OU3 since the development of this SAP. Thus, no data have been collected. (Note: Script 5B has been superseded by the *OU3 Wildfire Contingency Air Monitoring Plan* [EPA 2013].)

Script 6. This script was designed to provide data on residential exposures from LA in air during authentic forest fires in OU3. As noted above, no wildfires have occurred in OU3 since the development of this SAP. Thus, no data have been collected. (Note: This script and the associated SAP Addendum that was created to support a fire fighter ABS effort have been superseded by the *OU3 Wildfire Contingency Air Monitoring Plan* [EPA 2013].)

All ABS was conducted by MWH. A Phase IV Part A field data summary report has not been developed.

The ABS air filters were sent to Hygeia Laboratories, Inc. for analysis of LA by TEM. Filters were prepared and analyzed in basic accordance with ISO 10312:1995(E) with all applicable Libby site-specific laboratory modifications.

Detailed analytical results for all Phase IV Part A ABS air samples are provided in the OU3 project database (see **Appendix A**). The following section summarizes these results.

8.2.2 Asbestos Results

Table 8-2 presents the detection frequency and summary statistics for total and PCME LA in ABS air for each ABS area stratified by script. As shown, there were 10 ABS air samples collected for each script in each ABS area (i.e., 5 sampling events x 2 ABS personnel). Despite attempts to limit particulate loading on the collected air filter (by decreasing the sampling duration, reducing the flow rates, and splitting the sampling across multiple filters) nearly half of all ABS air samples required indirect preparation prior to analysis. Indirect preparation is known to increase structure counts due to dispersion of bundles and clusters (HEI-AR 1991; Breysse 1991). However, for LA, most structures occur as free fibers, and bundles and clusters are not common. Thus, indirect preparation at the Libby site is not believed to be a significant source of bias.

The mean concentration of total LA varied over an order of magnitude depending on the ABS area and the activity performed. The frequency of detection and LA air concentrations were generally highest along lower Rainy Creek during simulated recreational activities (Script 1). As shown in **Figure 8-4**, measured air concentrations for several scripts tended to be highest in ABS-07, the "middle" area.

For the residential wood harvesting ABS scenarios (Script 2A and 2B), LA was not detected in any ABS sample from any area for personnel simulating residential wood harvesters driving to and from wood harvest areas (Script 2A). As noted above, Script 2B activities which included cutting and hauling firewood were split into two parts 2.B.1 (felling and limbing) and 2B.2 (cutting and stacking) after the first round of sampling. Of the two scenarios, LA was detected more frequently and at higher concentrations during felling and limbing activities (Script 2B.1). Also, for Scripts 2B.1 and 2B.2, LA was detected more frequently and at higher concentrations in ABS-07. LA was not detected in ABS samples in ABS-02 for Scripts 2A and 2B.

For USFS forest management worker ABS scenarios (Scripts 3A, 3B, and 3C), no single activity was consistency associated with higher LA concentrations than another. However, the frequency of detection and LA concentrations were highest in ABS-07. Also, a higher frequency of detection was generally observed in all areas for Script 3B (thinning trees). Only one of the 30 ABS air samples collected in ABS-10 had detected levels of LA, and the single detection was associated with Script 3B activities.

For USFS firefighter ABS scenarios (Scripts 3D and 3E), LA concentrations were generally higher than those for forest management activities. The highest level of total LA and PCME LA were observed in ABS-07 for Script 3D (cutting firelines by hand using a Pulaski tool). In addition, the frequency of detection of LA was generally higher in ABS-07 than in ABS-02 or ABS-10.

9 Aquatic Toxicity Tests

Ecological risks are usually evaluated using an approach that relies upon multiple lines of evidence. Site-specific toxicity tests are often relied upon to provide information on the response of receptors that are exposed to site media. This may be done either in the field or in the laboratory using media collected on the site.

At OU3, two toxicity tests were conducted as part of the Phase II sampling program to evaluate the effect of fish and benthic invertebrate exposure to site surface water and sediment, respectively. The following sections summarize the study design and results of each toxicity test.

9.1 Surface Water Toxicity Test

9.1.1 Test Design

The surface water toxicity test design is detailed in the Phase II Part A SAP (EPA 2008a). In brief, the test was conducted with newly-hatched larval (sac fry) rainbow trout (*Oncorhynchus mykiss*) under static renewal conditions for an exposure duration of 6 weeks. Survival, behavior, and growth were observed during the exposure period, and the histopathology of the fish was examined at the end of the study.

Because the primary focus of this test was on evaluating the potential toxicity of LA in surface water, the water used in the test was selected by monitoring the levels of LA in OU3 waters in 2008, and choosing a time and place that was believed to be near the high-end of the observed range of LA concentrations to collect surface water for use in the toxicity test. Based on a real-time review[4] of the surface water concentrations in samples collected as part of the Phase II Part A sampling program (see Section 2.2), the tailings impoundment (station TP) was selected for evaluation in the site-specific surface water toxicity test. Surface water for use in the toxicity test was collected from the tailings impoundment on May 8, 2008. Water was shipped to Parametrix Environmental Research Laboratory (PERL) (a subcontractor to Remedium Group, Inc.) in Albany, Oregon for use in the toxicity tests.

Prior to performing the toxicity tests, a pilot-scale study was conducted to evaluate if the aquaria water circulation system was sufficient to keep LA fibers suspended in the test waters, thus ensuring the homogeneity of exposure solution. As part of this study, triplicate samples were collected from the top and bottom third of the water column in the aquarium and samples were sent to the EMSL Libby laboratory for rapid-turnaround analysis of LA by TEM. The results from this pilot-scale study (see **Table 9-1**) showed that there was no statistically significant difference, based on the Poisson ratio comparison test (Nelson 1982), between water

[4] This was accomplished by performing a preliminary rapid turn-around (within 24 hours) TEM analysis of surface water for a subset of the samples collected under Element 2. Rapid turn-around was accomplished by performing the TEM analysis without recording the detailed structure-specific information (i.e., structure type, length, width).

samples collected from the top of the aquarium and the bottom of the aquarium. This indicated that the water circulation system used in the aquaria was effective in ensuring that the LA in the water was well-mixed. Based on these results, the full-scale surface water toxicity test was initiated on May 22, 2008.

The site surface water was used to prepare a series of test dilutions as follows: 100% (undiluted site water), 10%, 1%, 0.1%, 0.01%, 0.001%, 0% (laboratory control water). At the test initiation, samples of the undiluted site surface water were collected and sent to the EMSL Libby laboratory for analysis of LA and to ELI for analysis of metals/metalloids. During the larval stage, water was changed once every 10 days, and after swim up once every 3 days, for a total of seven "cycles". For each round of static renewal, one composite water sample of each test dilution was collected shortly after the start of each renewal cycle, and one composite was collected at the end of the cycle. Samples from Cycle #1, Cycle #2, Cycle#4, and Cycle #7 were sent to the EMSL Libby laboratory for the analysis of LA by TEM, other water samples were archived at PERL.

9.1.2 Results

Detailed results of the 2008 OU3 site surface water toxicity test are presented in Parametrix (2009b). No significant effects on survival, growth (wet weight, length, condition factor) were detected for any test dilution. In addition, no unique lesions were evident in fish in the LA treatment groups, and the severity of lesions was not related to the LA treatment group.

Table 9-2 summarizes the measured total LA in the site surface water sample collected at the initiation (Day 0) of the study. Based the measured total LA concentration, the water concentrations in each test dilution were expected to be as follows:

Dilution	Expected Total LA Conc. (MFL)*
100%	~30
10%	3
1%	0.3
0.1%	0.03
0.01%	0.003
0.001%	0.0003

*Based on the rapid turn-around analysis results presented in Table 9-2

Table 9-3 summarizes the actual measured total LA water concentrations measured in samples from Cycles #1 and #7 for each test dilution. As shown, measured concentrations were significantly lower than expected for these cycles.

Table 9-4 summarizes the actual measured total LA water concentrations measured in samples from Cycles #2 and #4 for each test dilution. As seen, measured concentrations were lower than expected for these cycles.

9.1.3 Fiber Loss Pilot Washing Study

In order to investigate this apparent loss of LA fibers, a pilot-scale washing study was performed. This pilot study was intended to evaluate the hypothesis that LA fibers had adhered to a bio-film that was present in the mixing carboy and aquaria walls.

As described in the Toxicity of Asbestos in Waters from the Libby Superfund Site Operable Unit 3 (OU3) to Rainbow Trout (*Oncorhynchus mykiss*). (Parametrix 2009b**),** in this pilot study, samples collected during Cycles #2 and #4 were analyzed using a 4-step method as follows:

> Step 1: The sample bottle was gently swirled by hand to suspend any loose material and a 40 mL subsample was removed for TEM analysis.
>
> Step 2: A second 40 mL subsample was removed, placed in a clean beaker, and sonicated for 15 minutes. The sample was then analyzed by TEM. The purpose of this sonication was to disrupt and disperse any fibers that were in suspension but clumped together.
>
> Step 3: A solution of 0.1 M sodium chloride + 0.1 M Graham's salt (sodium hexametaphosphate) was added to the sample bottle to restore the sample volume to the original level. The sample bottle was sonicated and treated with ultraviolet (UV) light and ozone in accordance with Step 6.2 of EPA Method 100.1. The sample was then analyzed by TEM. The purpose of this treatment was to release and oxidize any microbial growth that may have been present on the walls of the bottle that may have trapped fibers.
>
> Step 4: Step 4 was not performed. This step was to determine if any remaining fibers adhered to the bottle wall. Planned steps were to cut the bottle open and remove a piece of the bottle about 1 cm^2 and submit this sample for examination by TEM.

Results from the four samples from Cycles #2 and #4 used in this pilot-scale washing study are shown in **Table 9-5**. Inspection of these findings suggested the following:

- There was a loss of fibers from the water in the sample bottles. This loss could be accounted for by calculating the total amount of LA in the bottles (in the water and on the bottle wall) and dividing by the volume of water in the bottle.
- There was a time-dependent loss of free fibers in the carboy used to hold the site water sample, with the loss beginning to be apparent sometime after the start of Cycle #2 (day 11 of the toxicity test).
- There was a clear loss of fibers in the aquaria during each cycle that cannot be attributed to a loss in the sample bottle.

The reason for the time-dependent loss of fibers in the carboy, the aquaria, and the sample bottles is not certain. However, the release of fibers in the sample bottles by ozonation and

sonication suggests that a microbial growth may be occurring that tends to clump fibers together and ultimately binds the fibers to the walls of the container vessel. Thus, trout exposures in the toxicity tests likely diminished substantially as the test progressed and the lack of adverse effects in the study may be due to a lack of exposure and not representative of the true toxicity.

9.2 Sediment Toxicity Test

9.2.1 Test Design

The sediment toxicity test design is detailed in the Phase II Part C SAP (EPA 2008c). In brief, site sediments were tested for toxicity using the amphipod *Hyalella azteca* in a 42-day test (EPA 2000; Test Method 100.4) for measuring the effects of sediment associated contaminants on survival, growth, and reproduction. Sediments were also tested for toxicity to the midge *Chironomus tentans* using the life-cycle test (EPA 2000; Test Method 100.5) for measuring effects on survival, growth, and reproduction.

The sediments used in these tests were selected to be near the high-end of the observed range of LA sediment concentrations in site streams and ponds. Based on a review of LA results for sediment samples collected in Phase I and Phase II sampling programs (see Section 3), two on-site locations (CC-1 and TP-TOE2) were selected for evaluation in the site-specific sediment toxicity test. In addition, sediments from the two off-site reference locations (BTT-R1 and NSY-R1) were also evaluated to provide a site-specific frame of reference for interpreting the results. Sediments for use in the toxicity tests were collected from October 14-17, 2008, and shipped to PERL. Aliquots of each sediment sample were also submitted for analysis of LA and metals/metalloids. The sediment toxicity tests were initiated on November 13-14, 2008, for *Hyalella* and *Chironomid*, respectively.

As part of the *Hyalella* toxicity test, a porewater pilot study was also conducted to quantify LA levels within the sediment porewater of each test material at Day 0 (study initiation) and at Day 28 (at the termination of the study portion of the test). Five replicates per treatment were fitted with a suction lysimeter which collected a 20 mL of porewater. Porewater samples from Day 0 were sent to the EMSL Libby laboratory and samples from Day 28 were sent to Hygeia Laboratories in Sierra Madre, California for the analysis of LA by TEM.

9.2.2 Results

Detailed results of the 2008 OU3 site sediment toxicity tests are summarized in Parametrix (2009c,d). Neither test organism (*Hyalella* or *Chironomid*) exhibited any statistically significant difference in survival, growth, or reproduction when compared to both laboratory control sediments and field-collected reference sediments.

Table 3-7 summarizes the measured LA concentrations in the site sediments (toxicity test samples are identified with a '*'). Concentrations of LA were 3% and 5% in the TP-TOE2 and CC-1 sediment samples, respectively, but were non-detect in sediments from the reference

areas. **Table 9-6** summarizes measured metal concentrations in site sediments. As seen, concentrations of most metals in sediment were generally higher in samples from OU3 than in samples from reference areas. Also, concentrations of metals in sediment samples from TP-TOE2 were higher than those reported in CC-1.

Table 9-7 summarizes the measured total LA concentrations in the sediment porewater during the *Hyalella* toxicity tests. (Note: In this table, concentrations are expressed as billion fibers per liter [BFL], not MFL.) As shown, porewater concentrations tended to be highly variable across replicates, and concentrations tended to be much higher on Day 0 compared to Day 28. However, these results are likely influenced by difficulties noted in the sample collection process, which resulted in the presence of variable amounts of sediment in the porewater samples.

10 Aquatic Community and Habitat Surveys

Another line of evidence that is often relied upon in the evaluation of ecological risks is direct observations of ecological community and habitat metrics. These observations seek to determine whether any receptor population has unusual numbers of individuals (either lower or higher than expected), or whether the diversity (number of different species) of a particular category of receptors (e.g., plants, fish, small mammals, birds) is different at the site than expected (relative to a selected reference area).

At OU3, direct observations (surveys) of the aquatic community and habitat were made during the 2008 and 2009 field seasons as part of the Phase III sampling program. In addition, a stream pool classification evaluation was performed in 2011 as part of the Phase IV Part B sampling program. The following sections summarize the study design and results of the aquatic community and habitat surveys.

10.1 Fish Community

10.1.1 Survey Design

Surveys of fish density and diversity were performed in October of 2008 and September 2009. A total of nine stream locations were evaluated, including two in upper Rainy Creek (URC-1A and URC-2), four in lower Rainy Creek (LRC-1, LRC-2, LRC-3, and LRC-5), one location downstream of the tailings impoundment (TP-TOE2) and at two off-site reference locations (BTT-R1 and NSY-R1) (see **Figures 10-1** and **10-2**).

In 2008, fish were collected using electroshocking equipment. Multiple passes of electroshocking were performed at each sampling location. In 2009, minnow traps were used in addition to the electroshocking passes in an effort to increase the effectiveness of capturing smaller fish. Length, weight, and species type were recorded for each fish collected. Detailed information on the fish community sampling efforts is provided in Parametrix (2009a, 2010).

10.1.2 Results

Table 10-1 summarizes the results from these sampling efforts. In this table, sampling information is provided separately for large fish (length > 65 mm) and small fish (length ≤ 65 mm). After a review of the data for fish caught in the minnow traps, it was determined that the openings on these minnow traps may have been too large (~25 millimeters [mm] in diameter) to effectively capture smaller fish (Parametrix 2010). Therefore, fish from the minnow traps were not included in fish community metrics. **Figure 10-3** summarizes the number of fish caught per acre by species at each sampling station during the first and second electroshocking passes[5]. In this figure, larger fish (length > 65 mm) are summarized in Panel A and smaller fish (length ≤ 65 mm) are summarized in Panel B.

[5] Because a 3rd electroshocking pass was not performed at all stations, this figure presents the total number of fish per acre based on 1st and 2nd pass electroshocking data only.

Based on the species identification of the larger fish, lower Rainy Creek stations are populated mainly by rainbow trout, though cutthroat trout were present at station LRC-5 in 2009. Cutthroat trout and cutbow trout (cutthroat/rainbow hybrids) tend to be predominant in upper Rainy Creek and Noisy Creek. Bobtail Creek tended to be populated with a mixture of brook trout and rainbow trout. As shown in Panel B of **Figure 10-3,** lower Rainy Creek stations had no fish ≤ 65 mm in length.

Detailed results for the fish community survey are provided in **Appendix D**.

10.2 Benthic Macroinvertebrate Community

10.2.1 Survey Design

Surveys of benthic macroinvertebrate (BMI) density and diversity were performed in 2008 and 2009 at the same site and reference sampling stations where fish surveys were performed (see **Figures 10-1** and **10-2**). At each location, BMI samples were collected using two different protocols. One sample was collected according to the EPA Rapid Bioassessment Protocol (RBP) method (Plafkin et al. 1989; Barbour et al. 1999), and one sample was collected using U.S. Forest Service (USFS) Surber methods (Barbour et al. 1999). For each sample, invertebrates were identified to the genus level and the relative abundance of each taxon was determined. Detailed information on the BMI sampling efforts are provided in (Parametrix 2009a; 2010).

10.2.2 Results

RBP Samples

The BMI community data collected in accordance with the RBP method are interpreted by combining a number of alternative metrics of benthic community status to yield a biological condition score (BCS), as illustrated in **Figure 10-4**. The BCS values from site stations are compared to BCS values for appropriate reference stations and a biological condition category is assigned for each sampling location.

Table 10-2 and **10-3** present the calculated benthic community metrics, the BCS, and assigned biological condition category for each sampling location for 2008 and 2009, respectively. As seen, in 2008, all lower Rainy Creek stations were ranked as slightly impaired and all upper Rainy Creek stations were ranked as unimpaired relative to the off-site reference areas. In 2009, with the exception of LRC-1 and LRC-2, all upper and lower Rainy Creek stations were ranked as slightly impaired relative to the off-site reference areas. LRC-1 and LRC-2 were ranked as unimpaired.

Surber Samples

As illustrated in **Table 10-4**, the Surber samples are interpreted by calculating a BMI total score from a number of benthic community metrics using a set of scoring criteria established by MDEQ for montane streams (MDEQ 2005). Metrics differ in their possible values ranges as well as in the direction the values move as biological conditions change. To facilitate scoring metric

values were transformed into a single scale and assigned a point score between zero to three. A score of three indicates a metric value similar to one characteristic of a non-impaired condition. A score of zero indicates strong deviation from non- impaired conditions and suggests severe degradation of biotic health. **Tables 10-5** and **10-6** present the benthic community metrics and the BMI total score for each OU3 sampling location for 2008 and 2009, respectively. Lower Rainy Creek sampling locations generally had scores at or slightly below the low end of the biological condition scoring range indicting impaired conditions. However, scores for Bobtail Creek (BTT-R1) and upper Rainy Creek (URC-1A) also indicated impaired conditions for some metrics in one or both years.

10.3 Habitat Assessment

10.3.1 Survey Design

Because variations in habitat can contribute to differences in aquatic populations between stations, a habitat assessment was completed at each aquatic community survey location using procedures from the EPA RBP method (Plafkin et al. 1989; Barbour et al. 1999). Ten alternative measures of habitat quality were combined to yield an overall habitat quality score (HQS) for each sampling location that reflects overall habitat quality. For each site sampling location, a relative score (percent of reference) was also calculated. This relative score indicates how closely habitat quality was matched to the reference station.

10.3.2 Results

Tables 10-7 and **10-8** present the HQS for each metric, the overall HQS, and assigned habitat ranking for each sampling location for 2008 and 2009, respectively. As seen, habitat quality at site stations was ranked as suboptimal to optimal, with HQS values tending to be fairly similar across the sampling locations (HQS values for lower Rainy Creek ranged from 120 to 169). Station LRC-1 had the lowest HQS in both 2008 and 2009. LRC-1 is located just below the Mill Pond in Rainy Creek, and scored lower than other stations for available cover, depth, and channel integrity. HQS values for reference stations ranged from 161 to 165 and were similar to upper Rainy Creek stations.

10.4 Stream Pool Assessment

In 2011, the Phase IV Part B data collection efforts included efforts to better characterize the habitat suitability of site streams for fish.

10.4.1 Sampling Design

In addition to surface water LA concentration data (see Section 2.4), the Phase IV Part B study included the collection of stream pool characteristics in OU3 to provide information on habitat factors that may influence fish populations. In small streams, the high temperature in water during the summer is an important factor in determining habitat suitability for fish. Access to deeper pools, where water is cooler, is critical for fish to escape excess heat in the summer, and

also to prevent freezing in the winter. Although stream habitat and surface water temperature data were collected in earlier investigations, additional surface water temperature data and more detailed characterization data of the in-stream pools were needed to utilize habitat suitability index (HSI) models for cutthroat and rainbow trout to evaluate the suitability of Rainy Creek to support and sustain fish populations (Hickman and Raleigh 1982; Raleigh *et al.* 1984) and to assess whether habitat factors are influencing fish populations in Rainy Creek . HSI models for salmonids use estimates or measurements of 16 different habitat variables to evaluate habitat suitability over all life stages. The Phase IV Part B habitat data were collected to provide information for HSI model variables V_1 (average maximum water temperature) and V_{15} (pool class rating).

To ensure that the reaches evaluated in the stream pool assessment were comparable to the fish community metrics collected in 2008 and 2009, the same nine reaches sampled for the fish community evaluations were evaluated in the stream pool assessment (see **Figure 10-1**). The stream pool assessment was conducted at seven stream locations in OU3, including two in upper Rainy Creek (URC-1A and URC-2), four in lower Rainy Creek (LRC-1, LRC-2, LRC-3, and LRC-5), and one downstream of the tailings impoundment (TP-TOE2). Two reference locations in the vicinity of OU3 were also evaluated, including one location on a tributary to Bobtail Creek (BBT-R1) and another location on Noisy Creek (NSY-R1) (see **Figure 10-2**). Global positioning system (GPS) coordinates for each stream reach are provided in **Table 10-9**.

In order to ensure that the maximum pool temperature was captured, pool temperatures were continuously monitored at one-hour intervals using a temperature data logger during the warmest portion of the year (i.e., summer months). Temperature monitoring began in June 23, 2011 and extended through October 4, 2011. Temperature monitoring data were collected from the deepest pool within each reach.

The stream pool assessment was performed in September 2011, when stream flows were at their lowest. For each reach, each identified pool was assigned a pool class based on its depth and size (length, width) as follows:

Pool Class	Description
1	Large[6] and deep. Pool depth and size are sufficient to provide a low velocity resting area for several adult fish. More than 30 percent of the pool bottom is obscured due to depth, surface turbulence, or the presence of structures, for example, logs, debris, boulders, or overhanging banks and vegetation. The pool depth is $\geq$ 1.0 meters deep (in streams < 5 meters wide). Note: Rainy Creek averages < 2 meters in width.

[6] Although the pool class descriptions use size descriptors of "large", "moderate", and "small", the HSI models do not specify any areal requirements for pool size.

Pool Class	Description
2	Moderate size and depth. Pool depth and size are sufficient to provide a low velocity resting area for a few adult fish. From 5 to 30 percent of the pool bottom is obscured due to depth, surface turbulence, or structures. Typical second class pools are large eddies behind boulders and low velocity moderately deep areas beneath overhanging banks and vegetation. Pool depth may range from 0.3 meters to <1.0 meters.
3	Small or shallow or both. Pool depth and size are sufficient to provide a low velocity resting area for one or two adult fish. Cover, if present, is in the form of shade, surface turbulence, or very limited structure. Typical third class pools are wide, shallow pool areas of streams or small eddies behind boulders. Virtually the entire bottom area is discernable. Pool depth is <0.3 meters.

Then, each reach was assigned a pool class rating (A, B, or C) depending upon the surface area coverage of each pool class as follows:

A: > 30% of the reach is comprised of Class 1 pools
B: > 10% to < 30% Class 1 pools, or > 50% Class 2 pools
C: < 10% Class 1 pools and < 50% Class 2 pools

The stream pool assessment and pool temperature monitoring effort was conducted by Anchor QEA, LLC (a subcontractor to Remedium Group, Inc.). Data from this study were reported in the *OU3 and Reference Stream Pool Assessment Data Report* (Anchor QEA, LLC [Anchor QEA] 2011). Major findings are summarized below.

10.4.2 Pool Temperature Monitoring Results

Figure 10-5 presents the stream pool temperature monitoring results for each reach and **Table 10-10** presents summary statistics of these results. **Table 10-11** presents stream pool temperature monitoring results by month. Based on a review of the pool temperature data collected for this study, the following observations are noted:

- There are clear differences in stream pool temperatures when comparing the different stream locations. The upper Rainy Creek locations (shown in Panel A of **Figure 10-5**) are cooler than the lower Rainy Creek locations (shown in Panel B of **Figure 10-5**). The reference site in Bobtail Creek (BTT-R1) is much warmer than the reference site in Noisy Creek (NSY-R1).

- Maximum temperatures observed in lower Rainy Creek were generally in the 14 to 18°C range, which are within tolerable ranges for cutthroat and rainbow trout (Hickman and Raleigh 1982). Maximum temperatures observed at Bobtail Creek (~20°C) would be less suitable for cutthroat trout.

- The locations not influenced by an upstream pond (NSY-R1, URC-1A, URC-2, and TP-TOE2) tend to have cooler temperatures than the stream locations affected by an upstream pond.

- The warmer pool temperatures in lower Rainy Creek and Bobtail Creek are likely due to the ponds located above these sites. The cooler pool temperatures measured at the upper Rainy Creek sites are likely due to groundwater sources recharging the stream water (Anchor QEA 2011).

- Riparian cover did not appear to be an important factor in measured pool temperatures (Anchor QEA 2011).

10.4.3 Stream Pool Assessment Results

An expanded stream survey area (i.e., stream reach length was extended 10 meters in each direction) was used in conducting the pool size assessment; however, for NSY-R1 and URC-1A, the stream reach evaluated for the pool size assessment was expanded even further upstream to include the deepest pool used in the temperature assessment. In this evaluation, pool lengths, widths, and depths[7] were measured and the length and average widths of each stream reach were calculated. **Figure 10-6** presents the pool area coverage (in percent) stratified by pool class for each stream reach. **Table 10-12** summarizes stream pool area measurements and classifications. Based on a review of the pool size characterization data for this study, the following conclusions can be drawn:

- Only one stream location (reference area NSY-R1) had a class 1 pool. There was only a single class 1 pool noted for this reach.

- With the exception of BTT-R1, all locations were dominated by class 2 pools.

- Reference site BTT-R1 had the least amount of area covered by pools. The upper Rainy Creek site, URC-1A, had the most area covered by pools.

Note: At the time of the pool size assessment at BTT-R1, the field teams noted that there were some signs of scouring that were not present when the pool temperature logger was placed. The scouring implies that there was an increase of flow. It is believed that there was a release of water from the private pond upstream of BTT-R1 (Anchor QEA 2011).

[7] Pool depth was calculated by subtracting the depth of the pool tail crest from the maximum pool depth.

11 Small Mammal Community Surveys

As noted above, direct observations of the ecological community at a site are often used as one line of evidence in the assessment of potential ecological risks. In the case of small mammals, because there are no accurate and representative data on measures of LA exposure (dose) of small mammals to site media, and because there is no reliable dose-response relationship for LA small mammals, the ecological risk assessment will rely on small mammal community surveys to provide information on potential effects at the OU3 site (EPA 2008d).

Direct observations (surveys) of the small mammal community were made during the 2009 field season as part of the Phase III sampling program. The following sections summarize the study design and results of the small mammal community surveys.

11.1 Survey Design

Revision 1 of the Phase III SAP (EPA 2009b) summarized several alternative strategies for the investigation of potential risks to small mammals that were considered by EPA. After deliberation with the OU3 Biological Technical Assistance Group (BTAG), it was determined that the Phase III small mammal community survey would seek to evaluate if individual mammals from an LA-contaminated forested area have a higher incidence and severity of histological lesions and/or gross deformities than mammals from a reference area.

In order to maximize the probability of detecting *in-situ* effects if they are present, the small mammal survey was performed at a location in the forest area where exposures to asbestos were expected to be highest based on the LA levels in forest duff, soil, and tree bark at OU3 (see **Figure 6-20**). Based on the duff data, a small mammal collection polygon for the forested area was established, which was bounded by four sampling locations where some of the highest LA concentrations have been measured in duff:

- SL-15-02 – LA concentration = 3.65% (2,230 Ms/g)
- SL-45-02 – LA concentration = 1.74% (3,082 Ms/g)
- SL-45-03 – LA concentration = 4.27% (2,630 Ms/g)
- SL-75-03 – LA concentration = 3.52% (3,146 Ms/g)

This set of four stations bounds a triangular polygon (see **Figure 11-1**) that covers an area of about 716,000 m^2 (72 hectares). After a site reconnaissance effort in June 2009 (Golder Associates Inc. 2010), trapping locations for the selected site area and a reference area in the Kootenai National Forest near Sheldon Mountain were identified (see **Figure 11-2** and **Figure 11-3**, respectively). **Table 11-1** provides coordinates of the OU3 and reference locations evaluated in this study.

Detailed information on the small mammal survey design is provided in Revision 1 of the Phase III SAP (EPA 2009b). In brief, trapping was planned for late summer during the driest time of the season and when small mammal populations are at peak levels to maximize potential LA releases from soil and Target animals were deer mice and southern red-backed voles. These

animals were targeted because they have small home ranges, forage on the ground, and have small body weights, and were the most common ground-foraging small mammals in Lincoln County. The number of animals desired was 30 animals per species per location (i.e., OU3 and reference), for a total of 120 animals per area. Equal number of males and females were desired to the extent possible.

Trapping and necropsy was performed between August 27 and September 2, 2009 by Golder Associates (subcontractor to Remedium Group, Inc.). Sherman live traps and Havahart® live traps were set one to three hours before dusk along trap lines at spacing intervals appropriate to field conditions and at least 15 feet apart along logging or forest roads. The steepness of the terrain and shrub density affected trap placement in some areas. Traps were checked one to two hours after sunrise and live target animals were transported to the field laboratory for field processing. Non-target species were released. After recording trap and animal identification information, the animal was euthanized. Each animal was examined for abnormalities and sex, and was measured, weighed, and photographed. Animal were stored on wet ice in a cooler until necropsy was performed. Eyeballs were removed for later use in aging. Animals were opened and the body cavity and viscera were photographed. Internal organs were examined for abnormalities and lesions. Tissue samples for possible future LA analysis were harvested and preserved by placement into formalin fixative for histopathological examination. Target tissues for collection for histopathological examination included: complete pulmonary tract, complete gastrointestinal tract, thyroid, and adrenals.

Details of the field collection efforts for the small mammal survey, including all field documentation, are summarized in the *Summer 2009 Small Mammal Data Collection Program* final data report (Golder Associates Inc. 2010). A summary of study findings are presented below.

11.2 Results

A total of 72 deer mice were collected as part of the small mammal survey, 34 mice from the reference sites and 38 mice from the OU3 sites. No voles were collected from either location. The overall female-to-male ratio for the animals captured from the reference area was 1.8, whereas this ratio was 0.8 for OU3. However, sex ratios between transects were variable at both the reference area and at OU3. Based on the average dry eye lens weight, the average mouse age ranged from 96 to 316 days (i.e., three to over ten months in age). A summary of the species and number of animals captured at each location is presented in **Table 11-2**.

Histological examination found no evidence of asbestos pathology in any target tissues or submitted lesions. Observed lesions were attributed to parasite- and disease-related inflammation by the pathologist. The pathologist also indicated that all mice had recognizable and abundant fat stores, which was indicative of adequate nutritional status. None of the mice had evidence of prominent stress response in the lymphoid tissues or the adrenals examined.

12 Quality Assurance/Quality Control

The purpose of this section is to describe the quality assurance (QA) procedures that have been established to govern the collection and analysis of environmental samples at OU3 to ensure resulting data are of high quality. This section also summarizes the results for a variety of different types of quality control (QC) samples that have been collected across the various sampling programs that provide information on the accuracy, precision, and reliability of reported results.

12.1 Field Quality Assurance Activities

12.1.1 General

Field QA activities include all processes and procedures that have been designed to ensure that field samples are collected and documented properly, and that any issues/deficiencies associated with field data collection or sample processing are quickly identified and rectified. Detailed information on field QA activities can be found in the investigation-specific SAP/QAPPs. These SAP/QAPPs are developed by EPA technical support contractors and implemented by Remedium field contractors. The following bullets summarize the components of the field QA program implemented at OU3.

- **Field Team Roles/Responsibilities –** There are a variety of field personnel involved in the sampling investigations for OU3 and each individual has assigned roles and responsibilities. The field team leader (FTL) oversees all sample collection activities to ensure that governing documents are implemented appropriately. The field QA manager is responsible for ensuring that all field efforts are conducted in accordance with appropriate QA guidelines.
- **Field Team Training** - Individuals involved in the collection, packaging, and shipment of samples must have appropriate training, including Occupational Safety and Health Administration (OSHA) 40-hour Hazardous Waste Operations and Emergency Response (HAZWOPER) and relevant 8-hour refreshers, respiratory protection, and asbestos awareness training.
- **Orientation –** Field personnel are required to attend an orientation session with the field Health and Safety (H&S) manager, as well as an orientation session on sample collection techniques.
- **Investigation-Specific Documentation** - Field personnel are required to review and understand all applicable governing documents associated with the sampling investigation, including the SAP/QAPP, all associated SOPs, and the applicable Health and Safety Plan (HASP).
- **Readiness Reviews** - Meetings are conducted prior to beginning field sampling activities to discuss and clarify the objectives, equipment and training needs, field SOPs, QC samples, and H&S requirements for each investigation.

- **Field Documentation Review –** Field documentation is completed by field staff using investigation-specific field forms. These field forms provide a standardized method of documenting sample information generated in the field. Field documentation is reviewed on a regular basis to ensure the accuracy of the recorded sample information.
- **Equipment Maintenance/Calibration –** All field equipment is maintained in accordance with manufacturer specifications and OU3-specific SOPs. For air samples, each air sampling pump is calibrated to the desired flow rate using a primary calibration standard prior to sample collection.
- **Equipment Decontamination –** Field equipment used in sample collection is decontaminated in accordance with OU3-specific SOPs. Any disposable equipment or other investigation-derived waste (IDW) is handled in conformance with SOP requirements.
- **Sample Custody/Tracking** - All samples collected at OU3 are tracked and managed in accordance with OU3-specific SOPs for sample custody and tracking using appropriate chain of custody (COC) forms.
- **Field QC Samples** - A variety of different types of field QC samples have been collected as part of the investigations conducted at OU3. These QC samples provide information on potential contamination arising from sample collection methods as well as information on result precision. (See Section 12.4.1 for a detailed discussion of field QC results.)
- **Modification Documentation –** Major deviations to the SAP/QAPP that modify the sampling approach and associated guidance documents are recorded on a field record of modification (ROM) form. These ROMs are reviewed and approved by the EPA RPM.

12.1.2 Field Oversight

Because field sampling activities at OU3 are performed by Remedium contractors, an important component of the field QA program is field oversight. From 2007 to 2009, field oversight was provided by EPA's contractor, CDM Smith. Starting in 2010, field oversight has been performed by EPA's contractor, HDR Engineering, Inc. (HDR).

Prior to initiating oversight activities, CDM Smith staff associated with the oversight activities reviewed all governing investigation-specific documents and prepared blank audit checklists to be completed during the field oversight activities.

In 2007, CDM Smith performed a field audit of ambient air station installation and sample collection for water, sediment, mine waste, forest soil, duff, tree bark samples collected as part of Phase I. A total of 10 audits were conducted from October 3 to October 18, 2007. In 2008, CDM Smith performed a field audit of flume construction, flow measurements, and collection of surface water and sediment samples for the Phase II, Part A investigation. A total of 41 field audits over 14 days in April 2008 were completed. Although some minor deviations were noted by the field auditor, there were no significant departures from the SAP/QAPP or SOPs in regards to sample collection or documentation that were noted in any of the CDM Smith field

oversight efforts.

In 2010, two HDR field oversight activities were performed during Phase IV, Part A ABS efforts in July and August. Oversight was conducted according to the Oversight Plans for each activity. HDR prepared the individual Oversight Plans to verify the activities occurred as detailed in the corresponding investigation-specific SAP/QAPPs. Photographs of the sampling activities, supporting figures, and field notebook documentation of HDR's oversight activities are presented at the end of each Oversight Report. In general, oversight activities were consistent with the strategy presented in the Oversight Plan. HDR noted some minor deviations, but the procedures and protocols outlined in the investigation-specific SAP/QAPPs were generally followed, and the overall program intent was met.

12.2 Soil Preparation Laboratory Quality Assurance Activities

12.2.1 General

Until 2012, all soil, mine waste, and sediment samples collected from OU3 were sent to the CDM Smith Close Support Facility (CSF) in Denver, Colorado for preparation prior to analysis by PLM. The *CSF Soil Preparation Plan (SPP)* (CDM Smith 2004) served as the guidance document for all activities at the CSF. The purpose of the *CSF SPP* was to provide standard guidance on preparation methods to ensure that these procedures and resulting measurements were scientifically sound and of acceptable and documented quality. The following bullets summarize components of the CSF QA procedures.

- **Personnel Training** - Individuals involved in the processing of samples are required to have read and understood the CSF SPP, all associated SOPs, as well as the facility health and safety plan. In addition, personnel must have appropriate training, including OSHA 40-hour HAZWOPER and relevant 8-hour refresher updates.
- **Documentation Review –** Sample preparation documentation is completed by CSF staff using Libby-specific forms. These forms provide a standardized method of documenting sample preparation information generated. This documentation is reviewed on a regular basis to ensure the accuracy of the recorded preparation information.
- **Equipment Maintenance/Calibration –** All weight scales, ventilation hoods, and drying ovens used in sample preparation are maintained and calibrated in accordance with manufacturer specifications. In addition, the plate grinder is calibrated daily, to verify proper particle size and demonstrate that samples are not being over-processed.
- **Equipment Decontamination –** Sample preparation equipment is decontaminated in accordance with Libby-specific SOP ISSI-LIBBY-01 between each sample.
- **CSF Contamination Monitoring –** The CSF performs regular contamination monitoring to evaluate worker safety, ensure laboratory cleanliness, and help assess the potential for cross-contamination of samples submitted to the facility.
- **Sample Custody/Tracking** - All samples collected processed at the CSF are tracked and managed in accordance with COC requirements specified in the *CSF SPP*.

- **Preparation QC Samples** - A variety of different types of preparation QC samples have been included in the preparation of sample collected as part of the investigations conducted at OU3. These QC samples provide information on potential contamination arising from sample preparation methods as well as information on result precision. (See Section 12.4.2 for a detailed discussion of preparation QC results.)
- **Modification Documentation** – Major deviations from the Libby-specific preparation SOP are recorded on a CSF ROM form. These ROMs are reviewed and approved by the EPA RPM (or their designee).

12.2.2 CSF Audit

The EPA Quality Assurance Technical Support (QATS) contractor (Shaw Environmental, Inc. [Shaw]) performed an audit of the CDM Smith CSF on October 2, 2008. Specific activities that were audited included the general laboratory facility, laboratory organization and personnel, general housekeeping, sample receipt and storage, sample preparation procedures, measurements and documentation, sample shipping procedures, and QA/QC procedures. The audit report was issued in March of 2009 (Shaw 2009). In brief, a total of 17 observed deficiencies were noted, as compiled from the completed summary on-site audit report, during the 2008 CSF audit (CB&I 2013a). The deficiencies identified during the audits were grouped into eight laboratory process areas. The laboratory process area categories in which the majority of the observed deficiencies occurred included bulk drying, sample receiving, and QA/QC (CB&I 2013a).

12.3 Analytical Laboratory Quality Assurance Activities

12.3.1 General

All laboratories selected for analysis of samples for asbestos are part of the Libby analytical laboratory team. These laboratories have all demonstrated experience and expertise in analysis of LA in environmental media, and all are part of an ongoing Libby-specific QA program designed to ensure accuracy of analytical and consistency of reported analytical results between laboratories. These laboratories are audited by the EPA QATS contractor and the National Institute of Standards and Technology (NIST)/National Voluntary Laboratory Accreditation Program (NVLAP) on a regular basis.

Laboratory QA activities include all processes and procedures that have been designed to ensure that data generated by an analytical laboratory are of high quality and that any problems in sample preparation or analysis that may occur are quickly identified and rectified. The following bullets summarize the laboratory QA procedures that are required of each laboratory that analyzes samples from OU3.

- **Laboratory QA Management Plan** - Each laboratory has developed a laboratory-specific QA Management Plan that provides a detailed description of the procedures and

policies that are in place at their laboratory to ensure laboratory quality.

- **Certifications** - All analytical laboratories are subject to national, local, and project-specific certifications and requirements. Each laboratory is accredited by the NIST/NVLAP for the analysis of airborne asbestos by TEM and/or analysis of bulk asbestos by PLM. This includes the analysis of NIST/NVLAP standard reference materials (SRMs), or other verified quantitative standards, and successful participation in two proficiency rounds per year each of bulk asbestos by PLM and airborne asbestos by TEM supplied by NIST/NVLAP.
- **Team Training/Mentoring Program -** Laboratories are required to participate in a training/mentoring program to ensure laboratories can demonstrate the ability to perform reliable analyses at the Site. The training process includes a review of morphological, optical, chemical, and electron diffraction characteristics of LA using site-specific reference materials, as well as training on project-specific analytical methodology, documentation, and administrative procedures used on the Libby site.
- **Technical Discussions/Conferences -** Laboratories participate in regular technical discussions with EPA and their contractors, as well as attend professional/technical conferences. These discussions enable the laboratory and technical team members to have an ongoing exchange of information regarding all analytical and technical aspects of the project.
- **Analyst Training -** All TEM and PLM analysts are required to undergo method-specific training and must understand the application of standard laboratory procedures and methodologies, including the Libby-specific analytical methods. Analysts must familiarize themselves with -the Libby-specific method deviations, project-specific documents, and visual references.
- **Data Reporting -** Standardized benchsheets and data entry spreadsheets have been developed specifically for the Libby project to ensure consistency between laboratories in the presentation and submittal of analytical data. All analysts are trained in the project-specific reporting requirements and data reporting tools utilized in transmitting results.
- **Laboratory QC Samples** - A variety of different types of laboratory QC analyses have been collected as part of the investigations conducted at OU3. These QC analyses provide information on potential contamination arising from laboratory preparation and analysis methods as well as information on result accuracy and precision. (See Section 12.4.3 for a detailed discussion of analytical laboratory QC results.)
- **Laboratory Contamination Monitoring –** Each analytical laboratory performs regular contamination monitoring to evaluate worker safety and ensure laboratory cleanliness in compliance with their SOPs and certification requirements.
- **Modification Documentation -** Changes or revisions needed to improve or document specifics about analytical methods or laboratory procedures are documented using a ROM form. These ROMs are reviewed and approved by the EPA RPM (or their designee).

12.3.2 Laboratory Audits

Each laboratory conducts internal audits of their specific operations on an annual basis using appropriate checklists in accordance with their laboratory-specific QA Management Plan. As noted above, the laboratories that are part of the Libby analytical laboratory team are also audited by the EPA QATS contractor on a regular basis to specifically evaluate adherence to all Libby-specific analytical requirements. On-site audits are used by EPA to verify samples analyzed by their contract facilities are being processed in accordance with EPA requirements. Each on-site audit involves a review of the general elements of preparation, on-site support, and report generation, which are modified as needed to fit the type of audit being performed.

A series of laboratory audits was performed in April-September of 2008 to evaluate all of the TEM and PLM laboratories that performed analyses in support of OU3. In addition, a laboratory audit of the Oregon State University (OSU) Aquatic Toxicology Laboratory[8], which performed the site-specific surface water trout toxicity tests for OU3 (see Section 9.1.2), was performed in June 2011. Detailed findings for each laboratory audit are documented in separate laboratory-specific audit reports. The overall conclusions of these laboratory audits are presented in CB&I (2013a) and summarized below.

Analytical Laboratories

A total of 63 observed deficiencies, compiled from the completed summary on-site audit reports, were identified from the on-site audits performed for four different analytical laboratories in 2008 (CB&I 2013a). The deficiencies identified in these laboratory audits were grouped into eight laboratory process areas. The laboratory process categories in which the majority of the observed deficiencies occurred included PLM, sample preparation, sample receiving, and QC/QA; whereas the laboratory process categories with the least frequently occurring deficiencies included TEM, facility, and data management (CB&I 2013a).

EPA requires that laboratories provide responses to on-site audit reports that include the laboratory's proposed corrective action to each of the identified audit deficiencies. Laboratory responses to the 2008 on-site audit reports were received from all the OU3 support laboratories. The laboratory responses provided proposed corrective actions for the identified findings along with objective evidence as applicable. No findings were contested. A subsequent round of laboratory audits (performed in 2012) shows that the number of deficiencies identified in 2012 decreased by almost 50%, which suggests that corrective action performed in response to previous audit findings were effective (CB&I 2013a).

OSU Aquatic Toxicology Laboratory

The audit of the OSU Aquatic Toxicology Laboratory involved an evaluation of the pilot study protocol for the toxicity test against the procedures used by the laboratory. These included the

[8] The OSU Aquatic Toxicology Laboratory noted in the QATS audit report and the PERL facility noted in Section 9.1.2 are the same.

shipping and receiving of test organisms, standards, and collected samples; the preparation and monitoring (physical and chemical) of test chambers; sample collection; a review of the laboratory's record keeping practices for shipping and receiving, test chamber preparation, and analytical measurements; the availability of written procedures; and the presence of a viable QA/QC program. Several on-site audit deficiencies were identified, including improper COC procedures, inadequate documentation, and deviations from the study protocol and governing SAP/QAPP that were not adequately communicated (CB&I 2013a). As noted in Section 9.1.2 above, there were a number of limitations related to the LA exposures that were also identified with the surface water toxicity test that limit the reliability and usability of the test results.

12.4 Quality Control Results

As discussed above, there are a variety of field QC samples, preparation laboratory QC samples, and analytical laboratory QC analyses are included as part of the sampling investigations performed at OU3. A detailed review and discussion of the results for all QC samples and analyses is provided in the annual QA summary report for OU3 prepared by the EPA QATS contractor (CB&I 2013a). The following sub-sections summarize the overall conclusions from this report.

12.4.1 Field Quality Control Samples

A variety of different types of field-based QC samples have been collected as part of investigations conducted at OU3. The investigation-specific SAP/QAPPs specify the types and frequency of field QC samples that were to be collected as part of each investigation. The types of field QC samples collected differ by media type, as follows:

- Lot blanks – air
- Field blanks – air, water
- Field duplicates/splits – air, water, soil, duff, tree bark
- Equipment rinsates - groundwater

A detailed review of the field QC sample results is provided in CB&I (2013a) and summarized briefly below.

<u>Lot Blanks</u>

A total of 14 air cassette lot blanks were analyzed by TEM. No asbestos structures were observed in any of the lot blanks analyzed. On this basis, the cassette lots were utilized for the ambient air and ABS programs.

Field Blanks

A total of 29 air field blanks and 38 water field blanks were collected from 2007 to 2011 and analyzed by TEM. LA was detected in only one water field blank (P1-00257) suggesting that there may have been potential contamination introduced during sample collection and/or analysis. Field blank P1-00257 was collected on 10/18/2007; however, there were no field samples associated with this field blank. Based on these results, it is concluded that contamination of air samples and water samples as a consequence of field collection and analysis methods is not of concern.

Field Duplicates/Splits

A total of 63 field duplicates and 4 field splits were collected from 2007 to 2011 and analyzed by TEM. The TEM results for the original and field duplicate/split samples are compared using the method for comparison of two Poisson rates described by Nelson (1982), based on a 90% confidence interval. Because field duplicate/split samples are expected to have inherent variability that is random and may be either small or large, there is no quantitative requirement for the agreement of field duplicates/splits. Results provide information on the magnitude of this variability and its effect on data interpretation.

The evaluation of field duplicates/splits suggests that the reproducibility of TEM results for air samples is good, but the reproducibility of water, tree bark, and duff TEM results (even within a small sampling scale) is difficult due to the inherent heterogeneity within the medium. In general, when field duplicate/split samples were statistically different from the original sample, concentrations were usually within a factor of about 3 for water samples and within a factor of about 10 for tree bark and duff samples.

A total of 28 field duplicates for soil-like media were collected from 2007 to 2011 and analyzed by PLM-VE. Field duplicate results are ranked as concordant (in agreement) if both the original sample result and the field duplicate result report the same semi-quantitative PLM-VE bin. Results are ranked as weakly discordant if the original sample result and the field duplicate result differ by one semi-quantitative bin (e.g., Bin A vs. Bin B1). Results are ranked as strongly discordant if the original sample result and the field duplicate result differ by more than one semi-quantitative bin (e.g., Bin A vs. Bin B2).

The evaluation of field duplicates for soil-like media shows that most field duplicates (~80%) were concordant with the original sample results. When results were discordant, they were only weakly discordant (i.e., within one bin). These differences may be due to analytical variability, but might also arise from authentic heterogeneity between the samples.

Equipment Rinsates

A total of 5 equipment rinsates were collected in Phase II Part B as part of groundwater collection efforts and analyzed by TEM. LA was detected in one equipment rinsate (concentration of 0.35 MFL based on total LA). This indicates that the decontamination procedures applied were not effective and that LA may have been introduced into the groundwater samples due to cross-contamination. Two groundwater field samples (P2-00780 and P2-00781) were collected on the same day with this equipment rinsate; total LA concentrations in these two field samples ranged from non-detect to 0.1 MFL based on total LA. Due to the contamination in the equipment rinsate, these two samples were FB-qualified.

12.4.2 Preparation Laboratory Quality Control Samples

The CSF preparation QC samples are used to ensure that the preparation techniques utilized to process soil-like samples at the CSF did not introduce potential contamination and to evaluate variability associated with preparation techniques.

There are two types of CSF QC samples that were evaluated at the Libby site: preparation blanks (including both grinding blanks and drying blanks) and preparation duplicates. A detailed review of the preparation QC sample results is provided in CB&I (2013a) and summarized briefly below.

Preparation Blanks

All preparation blanks that were inserted along with OU3 soil-like samples were ranked as non-detect (Bin A) by PLM-VE. These results show that the drying and grinding preparation procedures utilized within the CSF did not introduce LA contamination.

Preparation Duplicates

From 2007 to 2011, a total of 32 preparation duplicates were prepared by the CSF and analyzed by PLM-VE. Comparison of the preparation duplicate results with the paired original field sample results helps to evaluate the variability that may occur during sample preparation and analysis. Similar to field duplicates, preparation duplicates are ranked as concordant if both the original sample results and the preparation duplicate results display the same semi-quantitative classification. Most (~80%) of the preparation duplicates were ranked as concordant. When results were discordant, they were only weakly discordant. These results suggest that the PLM-VE results are generally reproducible and reliable and are not greatly influenced by differences in laboratory preparation and analysis techniques.

12.4.3 Analytical Laboratory Quality Control Samples

TEM

The laboratory QC requirements for TEM analyses at the Libby site are patterned after the requirements set forth by NVLAP, and include:

- Laboratory blanks
- Repreparations
- Recounts (i.e., recount same, recount different, and verified analyses)
- Inter-laboratory analyses

A detailed review of the laboratory QC analysis results is provided in CB&I (2013a) and summarized briefly below.

Laboratory blanks. No asbestos structures were observed in any laboratory blank samples analyzed by TEM. These results indicate that the filter preparation and analysis procedures utilized within the analytical laboratories did not introduce asbestos contamination.

Repreparations. A total of 29 repreparation TEM analyses have been performed for OU3 samples analyzed from 2007 to 2011[9]. Repreparation analyses are compared to the original analysis using the ratio method for statistical comparison of two Poisson rates recommended by Nelson (1982), based on a 90% Poisson CI. With the exception of two surface water repreparation analyses (collected as part of the Phase II-A investigaton), repreparation results were not statistically different from the original results. These results show that LA concentrations reported in the OU3 investigations have acceptable reproducibility and that TEM analytical precision is not likely to be impacted by filter preparation methods.

Recounts. More than 200 grid openings (GOs) and 700 structure pairs were re-examined as part of recount analyses for OU3 from 2007 to 2011. Recount analyses were compared with the original analysis on a GO-by-GO and structure-by-structure basis. GO concordance is evaluated based on a comparison of total structure count. Structure concordance is evaluated based on a comparison of the assigned mineral classification and recorded structure dimensions. The total structure counts matched for about 90% of all GOs, which ranks as acceptable concordance (per Libby laboratory modification LB-000029). When the same structure was observed and recorded, there was 100% agreement on the assigned mineral class and good agreement (91% for length; 98% for width) on the recorded structure dimensions. These results indicate that there is good result reproducibility between TEM analysts within the same laboratory.

[9] Note: CB&I (2013a) summarizes laboratory QC analyses performed through 2012. For the purposes of this data summary report, results are only included for analyses performed in studies conducted through 2011.

Inter-laboratory Analyses. More than 70 GOs and 200 structure pairs were re-examined as part of inter-laboratory analyses for OU3 from 2007 to 2011. Inter-laboratory analyses are special type of recount analysis, in which GOs are re-examined by a different laboratory than who performed the original analysis. Inter-laboratory analyses are compared in the same way as recount samples (described above). The total structure counts matched for only about 55% of all GOs, which ranks as poor concordance (per Libby laboratory modification LB-000029). When the same structure was observed and recorded, there was 98% agreement on the assigned mineral class for paired structures, which is ranked as acceptable (per Libby laboratory modification LB-000029). When mineral class differences were noted, it was usually related to differences in classification of "close call" non-asbestos material [NAM] (e.g., pyroxene). Although there was good agreement (94%) between laboratories on the recorded structure width, several discrepancies in recorded structure length were noted, and overall concordance was poor (71%). The TEM inter-laboratory analyses indicate there are differences structure identification and recording procedures between the TEM laboratories corrective action would be useful in achieving better agreement and reducing uncertainties due to between-laboratory differences.

PLM

Three types of laboratory-based QC analyses are performed for PLM-VE, including laboratory Duplicates (both self-checks and cross-checks), inter-laboratory analyses, and the performance evaluation (PE) standard analyses.

Laboratory Duplicates. A total of 47 PLM-VE laboratory duplicate analyses have been performed for OU3 samples analyzed from 2007 to 2011. Comparison of the laboratory duplicate results with the paired original field sample results helps to evaluate the variability that may arise during the PLM analysis. Similar to preparation duplicates, laboratory duplicates are ranked as concordant if both the original sample results and the laboratory duplicate results display the same semi-quantitative classification. Nearly all of the laboratory duplicates were ranked as concordant (only one analysis ranked as weakly discordant). These results indicate that the PLM-VE results are generally reproducible and reliable and are not greatly influenced by differences in analysis techniques within a PLM laboratory.

Inter-laboratory Analyses. A total of 16 PLM-VE inter-laboratory analyses have been performed for OU3 samples analyzed from 2007 to 2011. In general, the reproducibility of results between PLM-VE laboratories was poor for OU3 samples, with only about half of all inter-laboratory analyses ranked as concordant and many samples ranked as weakly discordant. The PLM-VE inter-laboratory analyses suggest that there are differences in methods and procedures between the PLM laboratories and corrective action is needed to achieve better agreement and reduce analytical uncertainties.

PE Standard Analyses. Libby-specific PE standards for soil have been created for use at the Libby site. These PE standards were created by spiking soil with known quantities of LA

obtained from the mine. A total of 40 PE standard analyses have been performed by the PLM laboratories that support OU3. About 80% of all PE standard analyses were concordant with the expected bin classification (as determined from the nominal LA level in the PE standard). When results were discordant, they were usually weakly discordant; however, there were two strong discordances noted for the highest PE standard, with reported results being biased low. These results demonstrate that PLM-VE results are generally accurate but there are inherent uncertainties associated with reported binned results.

12.5 Data Management Quality Assurance Activities

12.5.1 Database

Application

The master OU3 project database is a Microsoft Access® relational database that has been developed specifically for OU3. Due to the nature of asbestos analysis and other data reporting requirements, the database has been developed iteratively, expanding in its capabilities (and complexity) as project-specific needs have evolved. In addition to providing new functionality, as needed, enhancements have been made to accommodate data user needs and to incorporate various automated QA/QC procedures to improve data integrity.

Because data are continually being generated as a result of ongoing sampling and analysis at OU3, the project database is dynamic. Each day, new sample, analysis, and results records are added and records are corrected, as appropriate. As a result, any database-generated queries, tables, figures, maps, and reports provide only a "snapshot" of the database on the day the output was created. **Appendix A** provides a snapshot of the OU3 project database as of August 20, 2013. This snapshot was used to prepare all data summaries included in this report.

Administration and Security

Day-to-day operational control of the OU3 project database is under the control of EPA contractor, CDM Smith, including physical and network security, access rights, and data backup. The OU3 project database is kept on the CDM Smith server in Denver, Colorado. Incremental backups of the CDM Smith server are performed daily Monday through Friday, and a full backup is performed each Saturday. Access to the server is restricted to approved CDM Smith personnel only.

Data Entry Processes

The OU3 project database has a variety of built-in QC functions that improve accuracy of data entry and help maintain data integrity. For example, field data entry forms utilize drop-down menus whenever possible. Drop-down menus allow the data entry personnel to select from a set of standard inputs. The use of drop-down menus prevents duplication and transcription

errors and limits the number of available selections (e.g., valid media types). In addition, the project data allows a unique sample ID to only be entered once, thus ensuring that duplicate records cannot be created.

As noted above, the analytical laboratories are required to transmit results using Libby-specific electronic data deliverable (EDD) spreadsheets. Each EDD contains a variety of built-in QC functions that improve the accuracy of data entry and help maintain data integrity. For example, data entry forms utilize drop-down menus whenever possible to standardize data inputs and prevent transcription errors. In addition, many data input cells are coded to highlight omissions, apparent inconsistencies, or unexpected values so that data entry personnel can check and correct any errors before submittal of the EDD. These spreadsheets also perform automatic computations of analytical sensitivity, dilution factors, and concentration, thus reducing the likelihood of analyst calculation errors.

The transmitted EDDs are uploaded directly into the OU3 project database using upload queries in Microsoft Access® designed specifically for each type of EDD, which avoids potential errors related to manual entry of the results. Each upload query performs several integrity checks to ensure that records are consistent and complete prior to uploading the analytical data. If issues are identified, the analytical EDD will not be uploaded until they are rectified.

12.5.2 Non-Asbestos Data Validation

All data on the concentration of non-asbestos chemicals in surface water, sediment, soil, mine waste materials, and ground water were validated in accordance with the EPA Contract Laboratory Program (CLP) *National Functional Guidelines (NFGs) for Evaluating Organic Analyses* and *NFGs for Evaluating Inorganic Analyses*, modified for the methods used at OU3.
In brief, all non-asbestos data were evaluated based on the following parameters:

- Data Completeness
- Holding Times
- Gas Chromatography/Mass Spectroscopy Instrument Tune
- Calibrations
- Blanks
- Surrogate Recovery
- Matrix Spike/Matrix Spike Duplicates
- Laboratory Control Samples
- Internal Standards (if applicable)
- Field Duplicates (if applicable)
- Compound Identification
- Compound Quantitation and Reporting Limits
- System Performance
- Other Laboratory QC Specified by the Method
- Overall Assessment of Data

If QC criteria were not met, samples were qualified as follows:

R: Reported value is "rejected." Resampling or reanalysis may be necessary to verify the presence or absence of the compound.

J: The associated numerical value is an estimated quantity because the QC criteria were not met.

UJ: The reported quantitation limit is estimated because QC criteria were not met. Element or compound was not detected.

NJ: Estimated value of a tentatively identified compound. (Identified with a CAS number.) *Organics analysis only.*

U: The material was analyzed for, but was not detected above the level of the associated value. The associated value is either the sample quantitation limit or the sample detection limit.

NR: Result was not used from a particular sample analysis. This typically occurs when more than one result for a compound is reported due to dilutions and reanalyses.

The non-asbestos data validation was performed by EPA subcontractor, TLI. A summary of the non-asbestos data validation is provided in CB&I (2013b). In brief, inorganic, organic, and/or radiochemistry data for a total of 651 water and soil-like media samples in 29 sample delivery groups were reviewed by TLI. The OU3 project database (provided in **Appendix A**) includes all assigned data validation qualifiers. Any samples that were R-qualified (rejected) by the data validator should be excluded from use as the results are not reliable.

12.5.3 Asbestos Data Verification

Prior to the preparation of any data summary reports, a cursory data review is performed on any applicable data in the OU3 project database to identify data omissions, unexpected values, or apparent inconsistencies. Because analytical laboratories that utilize Libby-specific EDD spreadsheets, data checking of reported analytical results begins with automatic QC checks that have been built into these spreadsheets. In addition to these automated checks, as dictated by the governing investigation-specific SAP/QAPP, a more thorough data verification evaluation is also performed to ensure the consistency and quality of reported data.

Asbestos data verification includes checking that results have been transferred correctly from the original hand-written, hard copy field and analytical laboratory documentation to the OU3 project database. This data verification process utilizes Libby-specific SOPs developed to ensure

TEM and PLM results and field sample information in the OU3 database are accurate and reliable:

- EPA-LIBBY-09 – *SOP for TEM Data Review and Data Entry Verification* – This SOP describes the steps for the verification of TEM analyses, based on a review of the laboratory benchsheets, and verification of the transfer of results from the benchsheets into the project database.

- EPA-LIBBY-10 – *SOP for PLM Data Review and Data Entry Verification* – This SOP describes the steps for the verification of PLM analyses, based on a review of the laboratory benchsheets, and verification of the transfer of results from the benchsheets into the project database.

- EPA-LIBBY-11– *SOP for Field Summary Data Sheet (FSDS) Data Review and Data Entry Verification* – This SOP describes the steps for the verification of field sample information, based on a review of the FSDS form, and verification of the transfer of results from the FSDS forms into the project database. An FSDS review is performed on all samples selected for TEM or PLM data verification.

The goal of data verification is to identify and correct data reporting errors. The frequency of data verification is specified in each investigation-specific SAP/QAPP; typically, a minimum of 10% of sample and analysis results are verified.

There have been several data verification efforts performed in association with each OU3 investigation. Detailed results of data verification efforts and data quality conclusions are provided in the OU3 data verification summary report (see **Appendix E**). In brief, most of the issues identified during these data verification efforts were non-critical in nature, meaning that they were typographical errors and inconsistencies that were not expected to influence LA results and data interpretation. The frequency of critical errors (i.e., those that could influence LA results and data interpretation) was generally low. Error frequencies tended to be higher following particular programmatic changes in laboratory methods and data reporting requirements and at the beginning of sampling investigations.

All issues identified during the various OU3 data verification efforts were submitted to the field teams and/or analytical laboratories for resolution and rectification. All tables, figures, and appendices (including the OU3 project database provided in **Appendix A**) generated for this report reflect corrected data.

12.5.4 Asbestos Data Validation

Unlike asbestos data verification, where the goal is to identify and correct data reporting errors, the goal of asbestos data validation is to evaluate overall data quality and to assign data qualifiers, as appropriate, to alert data users to any potential data quality issues.

Until recently, there have been no formal data validation guidelines for asbestos. Thus, data validation efforts were performed by EPA technical contractors following the completion of each investigation and consisted primarily of a review and assessment of field and laboratory ROM forms, field QC data (e.g., field duplicates, field blanks), and laboratory QC data (e.g., recounts, repreparations) to evaluate potential data quality issues with respect to result precision, accuracy, representativeness, completeness, and comparability. No review of instrument calibration or control standard data was performed, as this type of information was included in the regular NVLAP certification process.

In late 2011, EPA released a draft of the *NFG for Asbestos Data Review* (EPA 2011b). These guidelines include review criteria and specific data qualifiers for validation of TEM, PLM, and PCM data. The EPA QATS contractor developed Libby-specific SOPs for data validation of asbestos datasets based on the draft asbestos NFGs. In 2013, the EPA QATS contractor performed a formal data validation of asbestos results for OU3 investigations conducted from 2007 to 2012. A detailed summary of this data validation effort is summarized in CB&I (2013a). The conclusions of this review are summarized below.

A total of 360 field samples (5%) from 30 different laboratory jobs analyzed by five different laboratories between 2007 and 2012 were selected for validation. Samples for validation were selected randomly, choosing samples that were representative across laboratory, analysis method, and media.

Very few OU3 asbestos data were qualified for analyses performed from 2007 to 2011. Only one laboratory QC analysis (recount different) was assigned a J-qualifier; no other OU3 analyses required qualification. Data for these this analysis was qualified due to the failure of the laboratory to perform and/or document daily calibration activities. Although several samples were affected by the lack of a daily calibration, they were not qualified due to the submission and review of other supporting laboratory documentation. The OU3 project database (provided in **Appendix A**) includes all assigned data validation qualifiers.

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